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Evaluation of Alternatives to Toxic Organic Paint Strippers

Carltech Associates, Columbia, MD

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EVALUATION OF ALTERNATIVES TO TOXIC ORGANIC PAINT STRIPPERS

by

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16. ABSTRACT

A study was undertaken to survey commercially available paint stripping formulations and identify those whose use would result in lower Total Toxic Organics (TTO, as defined in 40 CFR Part 413) loading in stripping operation wastewaters without decreasing the effectiveness or efficiency of the stripping operation. Data were gathered by means of a literature review, a survey of potential suppliers, and bench scale tests of alternative stripping formulations that were identified as having potential for reducing the level of released TTO.

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FOREWORD

The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water systems. Under a mandate of national environmental laws, the agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. The Clean Water Act, the Safe Drinking Water Act, and the Toxic Substances Control Act are three of the major congressional laws that provide the framework for restoring and maintaining the integrity of our Nation's water, for preserving and enhancing the water we drink, and for protecting the environment from toxic substances. These laws direct the EPA to perform research to define our environmental problems, measure the impacts, and search for solutions.

The Water Engineering Research Laboratory is that component of EPA's Research and Development program concerned with preventing, treating, and managing municipal and industrial wastewater discharges; establishing practices to control and remove contaminants form drinking water and to prevent its deterioration during storage and distribution; and assessing the nature and controllability of releases of toxic substances to the air, water, and land from manufacturing processes and subsequent product uses. This publication is one of the products of that research and provides a vital communication link between the researcher and the user community.

This project was undertaken to identify and evaluate commercial paint strippers with potential for reducing or eliminating sources of total toxic organics (TTO) released from U.S. Army refurbishing facilities. The information gained from this research adds to our basic knowledge for prevention or control of releases of toxic substances in wastewater discharges.

Francis T. Mayo, Director
Water Engineering Research Laboratory

ABSTRACT

A project was undertaken to identify commercial paint strippers that would be less hazardous than MS-111, a stripper containing phenol and up to 85% methylene chloride, that is used at many military and industrial refurbishing facilities. MS-111 and 10 alternative commercial paint stripping formulations were tested using a bench-scale simulation of processing steps used at the Sacramento Army Depot (SAAD). The effectiveness of each stripper was determined for immersion times of 20 and 35 minutes using coupon samples of eight different coating systems cut form stock material provided by SAAD. Relative toxicity and potential environmental hazards associated with each stripper were qualitatively evaluated to provide a ranking of alternatives.

Results indicated that SAAD should replace MS-111 with ENthone S-26 diluted in a 1:1 ration with water. Since the diluted S-26 contains about 25 % methylene chloride and 10% phenol, total toxic organics loading in the wastewater from this source can be decreased by as much as 60%. Further reduction can probably be attained by greater dilution of S-26 stripper with water, but more tests are needed to determine maximum dilution for effective stripping.

This report was submitted in fulfillment of Contract No. 68-03-3257 by Carltech Associates, Inc., under the sponsorship of the U.S. Environmental Protection Agency. This report covers the period May 15, 1985 to completion of work on the contract, January 31, 1986.

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SECTION 1

INTRODUCTION

BACKGROUND

The materials and equipment refurbishing activities at military installations throughout the country often result in significant pollution problems. Removal of old paint, rust, oil, dirt, or other surface coatings is necessary to prepare the surface for the application of new protective coatings. Removal of paint from aluminum is normally accomplished through use of organic solvents which often contain toxic compounds. Because these organic solvents are typically volatile and partially soluble in water, problems are often encountered in the surrounding work space and in the wastewater treatment systems (7,8).

One of the paint stripping formulations used extensively at military installations is MS-111, a solvent containing phenol and up to 85% methylene chloride. Because of its widespread use, methylene chloride is currently undergoing intensive study and investigation to determine the health and environmental affects associated with its use. MS-111 is currently used at the Sacramento Army Depot (SAAD), and methylene chloride has been identified as a major contributor to the total toxic organic (TTO) loading in the wastewater discharged from the facility. Its use could also increases potential air pollution problems and lead to the formation of hazardous waste sludges in the wastewater treatment systems.

Other commercial paint strippers are available which contain chemicals that are less hazardous than those contained in MS-111. However, no data were available on the performance of these alternative strippers when applied to the variety of paints and coatings used on military equipment. Acceptability could only be determined by systematic, controlled testing of the alternatives and the MS-111 stripper under comparable conditions.

OBJECTIVES

This project was undertaken to identify commercial paint strippers that would be less hazardous than MS-111 and to evaluate their effectiveness for the removal of paints typically used on the aluminum components encountered in the refurbishing of electronic equipment at the Sacramento Army Depot. The specific objectives were to:

1. Select up to a maximum of ten commercially available paint strippers which contain chemicals considered to be less toxic than methylene chloride and phenol, or which contain lower concentrations of these

chemicals than MS-111.

2. Rank candidate substitutes for MS-111 in accordance with their potential for pollution abatement and hazard reduction.

3. Conduct bench scale tests to provide data for comparative evaluation of the stripping efficiency of the alternatives with that of MS-111.

4. Evaluate the potential for reducing operating hazards and the TTO discharged to the wastewater treatment facilities at SAAD through the use of the most acceptable alternative stripper.

It should be noted that this project was limited to the conduct of a screening study of commercially available strippers used in accordance with the recommendations of the manufacturer or supplier of the material. No provisions were made for extending the experiments to cover the modification of commercially available strippers, or for the formulation of new strippers. Refinements in the formulation of effective strippers, and a thorough evaluation of health and environmental effects, were beyond the scope of work for this project.

SECTION 2

CONCLUSIONS

MS-111 and ten alternative commercial paint stripping formulations were tested in a bench scale setup simulating the processing steps used at the Sacramento Army Depot. The effectiveness of each stripper was determined for immersion times of twenty and thirty five minutes using coupon samples of eight different coating systems cut from stock material provided by SAAD. The relative toxicity and potential environmental hazards associated with each of the strippers was qualitatively evaluated to provide a ranking of alternatives from most desirable to least desirable from a pollution standpoint. Based on analysis and evaluation of the data obtained, CARLTECH has reached the following conclusions:

1. Of the commercial strippers tested, only strippers containing methylene chloride, phenol, and an organic acid effectively removed the top coat from all eight paint samples using a submersion time of 20 minutes.

2. The TTO loading in the wastewater from the stripping operation at SAAD can be lowered significantly by diluting a methylene chloride/phenol based stripper with water. Of the commercial methylene chloride based strippers tested only Enthone S-26 is specifically formulated and recommended by the manufacturer to be diluted with water. This stripper diluted in a 1:1 ratio with water effectively removed all types of paint used in the screening tests.

3. Further reduction in the TTO loading in the wastewater at SAAD may be attainable by greater dilution of methylene chloride based strippers with water. The minimum concentration of methylene chloride required for effective stripping action has to be determined by testing.

4. N-methyl-2-pyrrolidone exhibited potential as a basic ingredient in new stripper formulations for effective removal of paint from aluminum components. This conclusion is considered noteworthy since long term health and environmental hazards have not been identified in the limited data available on this compound. Additonal testing is required, however, to produce a completely effective stripping formulation and to fully evaluate health and environmental effects.

5. With the exception of epoxy based coatings, all paints tested can be effectively removed with Oakite ALM heated to 82°C (180°F). Oakite ALM contains no chemicals contributing to TTO in the wastewater.

SECTION 3

RECOMMENDATIONS

Based on the analysis and evaluation of the data obtained, and the conclusions cited above, it is recommended that:

1. The TTO loading in the wastewater at SAAD be reduced in the near term by using a diluted form of a methylene chloride/phenol/acid based stripper. A 50% dilution with water is recommended at this time based on available test data.

2. Additional bench scale testing be undertaken to determine the maximum dilution of methylene chloride/phenol/acid based strippers allowable for effective stripping of the coatings encountered in the refurbishing operation at SAAD.

3. A limited development program be undertaken to determine the feasibility of formulating an effective paint stripper based on n-methyl-2-pyrrolidone.

SECTION 4

METHODOLOGY

INVESTIGATION OF MS-111 PAINT STRIPPER

To establish a basis for evaluating alternative paint strippers, a study of MS-111 and its use in the refurbishing process was necessary. Early in the project, a meeting was held at the Sacramento Army Depot (SAAD). The scope of this project was reviewed with base personnel, the EPA Project Officer and a representative of the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA). The general requirements of the bench scale test program were established and it was agreed that SAAD would provide freshly painted panels to be used in the preparation of the paint sample coupons to be used in the test. Following this meeting an inspection of the refurbishing operations at SAAD was made. Special emphasis was placed on the details of the paint stripping process used at that facility.

The objectives of this initial field investigation were as follows:

1. To identify chemicals used in the cold stripping operation.

2. To document the operating techniques, procedures and processes involved in the refurbishing of military equipment.

3. To assess the performance of MS-111 in relation to applicable military specifications and the surface preparation requirements for the next step in the refurbishing process.

4. To study the equipment and processes use relative to the potential for release of toxic or hazardous materials to the air and wastewater effluents.

5. To determine the availability of items typically refurbished at SAAD for use in the test program.

6. To identify the types of paint normally encountered in refurbishing operations and to ascertain which have been found most difficult to remove.

Following the field investigation, additional information on MS-111 was obtained from the manufacturer and trade literature from the metals finishing and associated industries.

IDENTIFICATION OF ALTERNATIVE PAINT STRIPPERS

Review of trade journals and other literature from the painting and metals finishing industries provided the information necessary to develop a list of the companies involved in the production and/or distribution of commercial paint strippers. Letters were sent to 68 companies requesting information on commercial products suitable for removing paint from aluminum, with a preference for strippers which did not contain methylene chloride. Materials safety data sheets (MSDS), or other literature describing the chemical composition of the stripper, were requested. A list of the most promising candidates was developed by reviewing information from MSDS's (Appendix C), industry literature (7,8), general chemical references (9,10), and electronic data bases (1,2,3). Alternative strippers were screened first with the objective of eliminating methylene chloride and any other chemicals which contribute to TTO in wastewaters. Since methylene chloride was observed to be the basic chemical in most cold strippers, it was later considered prudent to include strippers on the basis of reduced methylene chloride content.

BENCH SCALE TEST PROGRAM

The bench scale test program was designed to simulate operating conditions at the Sacramento Army Depot and to provide performance data on alternative strippers for comparison with performance data on MS-111. Test procedures were prepared to obtain the following types of data:

1. The efficiency of removal of the paint finishes typically encountered in the SAAD refurbishing operation.

2. The effect of submergence time on paint removal efficiency.

The personnel conducting the tests were also instructed to note any abnormal precautions required in the handling of strippers, to record weight loss data on the coupons tested, and to provide detailed comments on the results of a visual inspection following the stripping and steam lansing operations (Appendix A).

Each stripping formulation was tested at immersion times of 20 and 35 five minutes using sample coupons from each of the eight different coating systems listed in Table 1. Each set of sample coupons were stripped for the prescribed time, neutralized in the caustic bath, rinsed in the water bath, and cleaned with a steam lance. Following the stripping operation, coupons were dried, weighed and photographed to document the results. Photographs were taken at both normal size and at 7X magnification to allow closer inspection of the stripped surface. The normal size photographs, used to document comparative results obtained for the eight coupons used in each test run, were taken in color with a polaroid camera. Although these pictures were useful in reviewing the results, no acceptable copies could be obtained for inclusion in this report. Examination of the photographs taken at 7X magnification added little to the analysis of the test results.

TEST EVALUATION PROCEDURES

Performance of each candidate stripping compound was evaluated against requirements of SAAD for surface preparation prior to application of new coatings, and was compared to performance of MS-111 on similar paint samples specifically prepared for the bench scale tests. Test results were also compared with operating results observed at SAAD. Only strippers which demonstrated capability to remove all types of paint provided as samples by SAAD, were considered to be viable alternatives to MS-111. As a final step, changes in stripping procedures or materials which might be required with each viable alternative were assessed to identify any major impact on processing rates and overall refurbishing costs at SAAD.

SECTION 5

RESULTS AND DISCUSSION

ASSESSMENT OF THE MS-111 PAINT STRIPPER

Chemical Composition

MS-111, the trade name of an epoxy stripper produced by Miller-Stephenson Chemical Company, Inc., contains about eighty-five percent (by volume) methylene chloride, ten percent phenol, five percent formic acid and less than one percent surfactant. The substance of greatest environmental concern is methylene chloride, a highly toxic chemical normally found in the wastewaters from metal refurbishing facilities. Methylene chloride is a major contributor to the Total Toxic Organics (TTO) found in the wastewaters from the SAAD facility. It enters the SAAD wastewater system principally through "dragout", a term applied to material which adheres to metal parts as they are removed from the stripping tank. This material is deposited in the rinse water, or removed in the hot water/steam lancing operation and discharged to the floor drain system.

The phenol contained in MS-111 also contributes to TTO in wastewaters. However, the phenol concentration in the wastewater is much lower since it is a minor component in MS-111. The manager of the stripping operation at SAAD indicated that equivalent formulations manufactured by Buckley Chemical and El Dorado Chemical, as well as pure methylene chloride, have been used routinely as make up for evaporation and "dragout" losses. Consequently, the percentage of phenol in the stripping tank is expected to be less than the ten percent listed in the formulation for MS-111.

Industrial Utilization

Methylene chloride based strippers are widely used in the metal finishing industry. Most acidic cold strippers have methylene chloride as a major constituent in combination with other organic solvents. Other chlorinated solvents, ketones and esters, are sometimes used as substitutes in strippers which do not contain methylene chloride (1). The rarity of commercially available cold strippers which do not contain methylene chloride was confirmed during the course of this project (2).

Refurbishing Operations at SAAD

The Sacramento Army Depot (SAAD) refurbishes communications and other electronic equipment and the enclosures used to house the equipment. Interior fixtures such as cabinets, drawers, brackets and other small metal parts are removed from the structure, stripped of their coatings, sand blasted, electroplated, and repainted. Fixtures fabricated from steel are normally cleaned and stripped of paint in a hot caustic bath. However, the major portion of the equipment encountered at SAAD is fabricated from aluminum; exposure to hot caustic liquid would cause severe corrosion. Aluminum is not generally attacked by cold acidic organic solvent-based strippers; the stripping performance of MS-111 at SAAD has been quite satisfactory.

Disassembled cabinets and fixtures are loaded into a large wire mesh basket and lowered into the cold strip (MS-111) tank for approximately twenty minutes. The exact submergence time in the stripper is left to the operators judgement, since stripping efficiency is often affected by the shape of the pieces and the way they are packed in the basket. The floor supervisor pointed out that use of an alternative stripper, which required a significantly longer stripping time, would seriously affect their ability to maintain normal throughput. After a short drainage period the basket is dipped briefly into a hot (77°C, 170°F) caustic solution to neutralize the acidity of the stripping solution. After draining the caustic solution, the basket is submerged in a water rinse tank. Metal parts are individually cleaned with a high pressure steam/hot water lance prior to transfer to the sandblasting operation. A line diagram of the processing steps is shown on Exhibit 1.

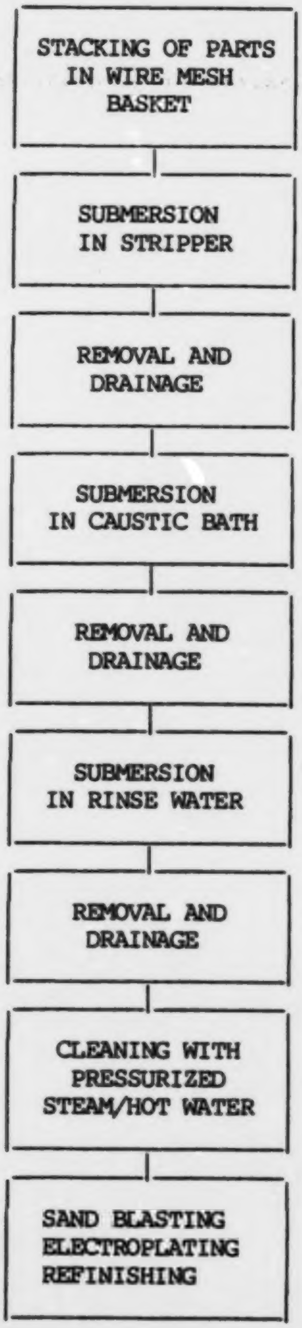
This process was observed many times during the initial site visit. The coating is not removed completely by the chemical stripper, but merely loosened to facilitate removal in the steam cleaning step. Zinc chromate primer used in some coating systems is not always removed by the cold stripper. This primer also remains essentially intact after steam cleaning and requires sandblasting for removal. There are no written specifications, analytical procedures, or field tests available to measure the effectiveness of the stripping operation. The decision to pass the material on to sand blasting is based solely on visual inspection by experienced personnel. Stripping effectiveness is judged by the ease with which subsequent processing steps, sandblasting, electroplating, and recoating, can be successfully accomplished.

SELECTION OF SAMPLES FOR BENCH SCALE TESTING

During the initial site visit to SAAD, base personnel discussed the types of paint normally encountered in the stripping process. Most substrates were aluminum, although an occasional steel fitting was encountered. The most difficult top coats to remove are considered to be navy gray enamel and various epoxy paints including Chemical Agent Resistant Coatings (CARC). Zinc chromate primer used in many of the coating systems is not always removed in the stripping operation. Aged coatings are normally more difficult to remove than recently applied finishes.

SAAD personnel did not believe it would be feasible to supply a sufficient number of small fittings with the variety of coatings desired for the testing of up to ten alternative strippers. It was therefore agreed that SAAD would prepare aluminum panels with the coatings of interest for

EXHIBIT 1. SACRAMENTO ARMY DEPOT - PAINT STRIPPING PROCESS


STACKING OF PARTS IN WIRE MESH BASKET
SUBMERSION IN STRIPPER
REMOVAL AND DRAINAGE
SUBMERSION IN CAUSTIC BATH
REMOVAL AND DRAINAGE
SUBMERSION IN RINSE WATER
REMOVAL AND DRAINAGE
CLEANING WITH PRESSURIZED STEAM/HOT WATER
SAND BLASTING
ELECTROPLATING
REFINISHING

this study. These panels were to be approximately 3 feet by 3 feet to assure that sufficient stock material would be available for the preparation of the test coupons required. The SAAD staff also agreed to provide a sufficient number of small pieces with aged coatings for proof testing of the most promising strippers.

The paint sample panels actually supplied for the bench scale tests were reduced in size to approximately 1 foot by 1 foot for ease in shipping. This necessitated a change in the test procedure to assure that sufficient coupons would be available for screening tests of all of the stripping formulations selected. The coupon size was reduced from 3 inches by 3 inches to 1 inch by 4 inches, and the three immersion times originally specified, were reduced to two periods of 20 and 35 minutes. The 10 minute period was discarded since the normal dipping time at SAAD is 20 minutes, and reducing the stripping time was not an objective of this study. Additional sample panels were later provided for the preparation of back-up test coupons, but were not required for completion of screening tests. The eight paint systems used in the screening test are identified in Table 1.

TABLE 1. IDENTIFICATION OF PAINT SAMPLES

CODE	MATERIAL	PRIMER	TOP COAT
A	Aluminum	Zinc	Enamel
B	Aluminum	Zinc Chromate	Enamel
C	Aluminum	Zinc Chromate	Enamel
D	Aluminum	Primer	Epoxy
E	Aluminum	Epoxy	Polyamide
F	Aluminum	Water Reducible	Polyamide
G	Aluminum	Zinc Chromate	Polyamide
H	Steel	Epoxy	Polyamide

IDENTIFICATION OF ALTERNATIVE PAINT STRIPPERS

A wide variety of mechanical, chemical, and physical methods for the removal of paint are used in industry. Mechanical methods include sanding, blasting with abrasives, chipping, and scraping. Burning, immersion in hot molten salt baths, and the use of cryogenic temperatures are generally considered to be physical methods for paint removal. Most chemical paint removal techniques involve the use of organic solvents or other chemicals designed to degrade the paint film structure or destroy adhesion of the film to the substrate.

Chemical strippers are commonly classified as hot or cold. Hot strippers are usually highly alkaline and formulated on a base of caustic soda. Most cold strippers are based on methylene chloride or similar organic solvents such as ketones and esters, and generally contain phenolics and aromatic hydrocarbons. Cold strippers may be acidic, basic or neutral. Some are produced in emulsion form to facilitate removal with water. Those containing phenols or cresols are usually acidic and can be rinsed with water. Chemical stripping is accomplished via several different mechanisms. The paint can be dissolved to form a solution with the solvent, or the paint film may be destroyed by chemical reaction with the solvent. In other cases penetration of the paint film, either directly or through scratches, holes, or broken edges, destroys its adhesion to the base material(7).

While some hot acid strippers can be used safely, most hot caustic strippers cannot be used on aluminum because of the severe corrosion of the substrate. Some modern finishes such as epoxies are designed to resist heat and alkaline attack . Therefore, use of a cold organic solvent formulation is generally the most practical method for removing paint from aluminum surfaces. These factors, along with the objective of identifying a replacement for MS-111 which could be used without extensive modification of the stripping process at SAAD, helped to focus the search for alternatives.

Contact with Potential Suppliers

During the month of June written requests for information on cold strippers and other products which could be effectively used for removing paint from aluminum, were sent to 68 companies. This initial inquiry stressed our preference for strippers that did not contain methylene chloride or any equally toxic organic solvent. Only three replies had been received by the middle of July. Our inquiry was later broadened to solicit information on any formulation which might be considered to have less environmental impact than MS-111. An intensive campaign was undertaken in which 48 of the companies who had been sent letters were again contacted by telephone. This produced responses from an additional eight companies. Although many of the strippers proposed contain some methylene chloride, six formulations were considered to have potential for reducing the TTO released. As the program progressed, three new strippers were identified for inclusion in the screening tests, one formulation was specified for testing in diluted form, and another was chosen to be tested hot. This brought the total number of screening tests specified to eleven, including the base line test of MS-111. Formulations tested are shown in Table 2.

BENCH SCALE TESTING

Test Specification And Protocol

The specification set forth functional requirements for the bench scale test so that the equipment and procedures used would closely simulate the actual conditions observed at SAAD's paint stripping facilities. Based on these functional requirements, detailed procedures were developed to assure that the sequence of events, time of submergence in each bath, and drainage time allowed, could be followed precisely and duplicated for each stripper

TABLE 2. CHEMICAL COMPOSITION OF CANDIDATE STRIPPERS

CODE	SUPPLIER	TRADE NAME	COMPOSITION *	
			CHEMICAL	PERCENT
I	Nalco Chemical Co.	84TB-227	Cyclic Amide	100
II	GAF	140641	N-methyl-2-pyrrolidone	100
III	Enthone, Inc.	S-26	Methylene Chloride	<50
			Phenol	<20
			Formic Acid	<5
IV	Savogran Co.	Stripeeze	Methylene Chloride	<20
			Toluene	<40
			Methanol	<30
			Acetone	<25
			Paraffin Wax	<2
V	Savogran Co.	Kutzit	Methylene Chloride	<30
			Methanol	<30
			Toluene	<30
			Acetone	<30
			Paraffin Wax	<2
VI	Mitchell-Bradford Chemical Company	Quick Strip-8	Methylene Chloride	60
			An Acid	-
VII	Miller-Stephenson Chemical Company	MS-111	Methylene Chloride	85
			Phenol	10
			Formic Acid	5
			Surfactant	<1
VIII	Oakite Products	ALM (Ambient)	Monoethyl Amine	10
			Furfuryl Alcohol	<10
			Tributyl Phosphate	<5
			Sodium Hydroxide	<1
IX	Oakite Products	FHS	Butyl Cellosolve	35
			Formic Acid	15
			Mixed Aromatics	10
			Diisobutyl Ketone	10
			Dodecylbenzene Sulfonic Acid	?
			Hydrofluoric Acid	<5
X	Oakite Products	ALM (180°)		
XI	Enthone, Inc.	S-26 Diluted 1:1 With Water		

* From materials safety data sheets or updated information from suppliers

tested. The test specification is included in Appendix A and the approved test protocol is provided in Appendix B.

Summary Comparison of Alternative Strippers

The conclusions reached in this report are based primarily on visual examination of the sample coupons similar to the procedure presently used at SAAD. Our analyses of stripping efficiency for all of the formulations tested on the specially prepared paint sample coupons are summarized in Tables 3 and 4. All strippers containing methylene chloride are identified by the letters MC after the code number. The percent removal is indicated in TABLE 3. for a stripping time of 20 minutes and in TABLE 4. for a stripping time of 35 minutes. In general, an increase in submergence time from twenty to thirty five minutes had little effect on the performance of the strippers.

The first three strippers performed equally well on all of the paint systems tested. Unfortunately, the effective strippers contain methylene chloride, phenol, and an organic acid. The fourth stripper, which was almost as effective as the first three, contains a high percentage of methylene chloride. Stripper XI, which was Enthone S-26 diluted 1:1 with water, contained the smallest amount of methylene chloride (less than 25%, based on the latest information received from the supplier). Diluted S-26 was as effective in removing all paints tested as MS-111. This conclusion was reinforced by results of subsequent tests using samples of aged coatings. Enthone S-26 diluted 1:1 with water, MS-111, and Quick Strip No. 8 were tested using small brackets supplied by SAAD with an immersion time of 35 minutes. The coatings on these brackets included; 1) a water reducible epoxy primer, 2) a water base primer with an epoxy topcoat, 3) a water base primer with a chemical agent resistant coating (CARC), and 4) a water base primer with an enamel topcoat. All three strippers effectively removed 100% of the topcoat on all samples.

Observations by the personnel performing the test indicated that both MS-111 and S-26 would probably have been equally effective with a twenty minute immersion time. Quick Strip No. 8 appeared to require longer for complete removal of the aged paint samples, similar to the results observed during the screening tests on new paint samples.

Assessment of Performance of Candidate Strippers

To obtain optimum performance, a cold organic paint stripper must contain one or more solvents capable of quickly penetrating the coating film to effect a release of the film from the base material without causing damage to the substrate. It is not normally desirable to completely dissolve the film since the coating may be re-deposited as drying occurs. The stripper may contain a number of additional compounds to facilitate the operation of the main solvent, increase versatility for removal of a variety of coatings, accelerate the stripping action, conserve volatile solvents, and/or provide the physical properties desired. These additives are generally classified as cosolvents, activators, corrosion inhibitors, evaporation retarders, thickeners, emulsifiers, or wetting agents.

TABLE 3. EFFECTIVENESS OF COMMERCIAL PAINT STRIPPERS*
20 MINUTE SUBMERGENCE

PAINT TYPE PAINT STRIPPER		Enamel on Zinc	Enamel on Zinc Chromate	Enamel on Zinc Chromate	Epoxy on Primer	Polyamide on Epoxy	Polyamide on Water Reduce	Polyamide on Zinc Chromate	Polyamide on Epoxy
VII MS-111	MC	100%	100&	100%	100%	100%	100%	100%	100%
III S-26	MC	100%	100%	100%	100%	100%	100%	100%	100%
XI S-26(Dil.)	MC	100%	100%	100%	100%	100%	100%	100%	100%
VI QS No.8	MC	100%	100%	99%	3%	100%	100%	100%	100%
X** ALM(Hot)		100%	100%	100%	0%	100%	100%	100%	100%
IX FHS		100%	100%	100%	0%	50%	95%	20%	0%
II***GAF 140641		100%	100%	50%	0%	0%	0%	0%	0%
I Nalco 84TB227		100%	100%	20%	0%	0%	0%	0%	0%
IV Stripeeze	MC	100%	100%	75%	0%	0%	0%	0%	0%
V Kutzit	MC	100%	100%	50%	0%	0%	0%	0%	0%
VIII****ALM		100%	100%	25%	0%	0%	0%	0%	0%

MC Contains methylene chloride

* Percent of top coat removed

** Stripper heated to 82° (180 $^{\circ}$F) as recommended by supplier.

*** Pure chemical compound, no commercial formulations available. Also recommended to be used hot, although not known prior to the test.

**** Same formulation as "X" tested at room temperature.

TABLE 4. EFFECTIVENESS OF COMMERCIAL PAINT STRIPPERS*
35 MINUTE SUBMERGENCE

PAINT TYPE PAINT STRIPPER	Enamel on Zinc	Enamel on Zinc Chromate	Enamel on Zinc Chromate	Epoxy on Primer	Polyamide on Epoxy	Polyamide on Water Reduce	Polyamide on Zinc Chromate	Polyamide on Epoxy
VII MS-111 MC	100%	100%	100%	100%	100%	100%	100%	100%
III S-26 MC	100%	100%	100%	100%	100%	100%	100%	100%
XI S-26(Dil.) MC	100%	100%	100%	100%	100%	100%	100%	100%
VI* QS No.8 MC	100%	100%	100%	99%	100%	100%	100%	100%
X** ALM(Hot)	100%	1005	100%	0%	100%	100%	100%	100%
IX FHS	100%	100%	100%	0%	50%	50%	10%	100%
II***GAF 140641	100%	100%	90%	55%	0%	0%	0%	0%
I Nalco 84TB227	100%	100%	95%	0%	0%	0%	0%	0%
IV Stripeeze MC	100%	100%	85%	0%	0%	0%	0%	0%
V Kutzit MC	100%	100%	70%	0%	0%	0%	0%	0%
VIII****ALM	100%	100%	25%	0%	0%	0%	0%	0%

MC Contains methylene chloride

* Percent of top coat removed

** Stripper heated to 180 °F as recommended by supplier.

*** Pure chemical compound, no commercial formulations available. Also recommended to be used hot, although not known prior to the test.

**** Same formulation as "X" tested at room temperature.

The strippers tested in this project contained a variety of solvents including methylene chloride, phenol, n-methyl-2-pyrrolidone, methanol, acetone, toluene, furfuryl alcohol, tributyl phosphate, butyl cellosolve, diisobutyl ketone, and an unspecified cyclic amide. In theory, the effectiveness of methylene chloride is due to its small molecular size which facilitates rapid penetration of paint films, and to its intermediate solvency for various polymer coatings. Swelling and lifting of the coating from the substrate is preferred over complete dissolution in the solvent, to avoid re-deposition problems. As methylene chloride penetrates to the substrate the film swells to several times its original volume. The swelling causes an increase in pressure at the interface with the substrate, and the resulting wrinkling and blistering causes release of the film from the substrate. Most of the stripper solvents cited above function in essentially the same manner, although some do actually break down chemical linkages, disrupt the continuity of the film, and partially dissolve the polymer. Methanol and phenol are often used as cosolvents to increase the versatility of the stripper in attacking coatings that resist the primary solvent.

The term "activator" is applied to additives which increase the rate of stripping. Methanol and other polar solvents fit this description in some applications. Acids, alkalies, and amines are also used as activators. The activators encountered in the strippers used in this project included formic acid, hydrofluoric acid, dodecylbenzene sulfonic acid, methanol, phenol, and monoethanolamine. The function of formic and other organic acids as activators in the removal of epoxy coatings is relatively clear. Organic acids tend to hydrolyze ether linkages in the film and facilitate rapid penetration by the solvent. In the case of some of the stripper formulations tested, it is not always clear as to whether the additive is expected to function as an activator or a cosolvent. In either case they are added to enhance and extend the performance of the primary solvent in the stripper.

The only evaporation retarder specifically noted in the formulations was the paraffin wax used in Stripeeze. This formulation contains acetone and toluene which are significantly more volatile than many of the other solvents encountered in this project. Also, the use of a surface active agent was only indicated in one formulation under the generic term "surfactant".

The exact formulation of chemicals used in paint strippers is often considered to be a trade secret. The new laws governing the control and use of toxic substances do require that the manufacturer identify all chemicals in a product that are proven health hazards if they constitute greater than 1% of the product. Carcinogens must be identified at greater than 0.1%. This information is contained in a Materials Safety Data Sheet (MSDS) prepared by the manufacturer or distributor. Even so, minor components which are important in the performance of a stripper may be identified only in general terms, or may not even be reported. For example, the use of an emulsifying agent was not indicated in the MSDS for the S-26 stripper although it is obvious that some additive of this type is required to facilitate dilution of methylene chloride with water. Also, some of the

MSDS's available to CARLTECH prior to completion of this project were prepared before more strict regulations became effective in November 1985. Within the limitations on the accuracy and completeness of the chemical data available, recognizing that the preparation of paint stripping formulations is somewhat of an art, an attempt has been made to reconcile the performance of the various strippers tested in this project from a theoretical standpoint.

Miller Stephenson Chemical Company (MS-111)--

MS-111 contains about 85% methylene chloride, 10% phenol, 5% formic acid and less than 1% of a surfactant. Methylene chloride is the major solvent in the formulation and the mechanism of its attack on paint films was discussed above. It is likely that phenol is used both as a cosolvent and an activator to increase the rate of penetration of methylene chloride into the paint film. Specifically, the polyamides are soluble in phenol but not in methylene chloride. Phenol is also an organic acid that could be useful in removing oxide films from the surface of the coating, thereby loosening the paint film and improving the penetration of the methylene chloride. Formic acid also helps in dissolving oxide films but is probably used primarily for its ability to hydrolyze ether linkages in epoxy paints and as a solvent for polyamides. The surfactant simply assures that the paint film is thoroughly wetted with the stripping solution.

The bench scale tests proved that this formulation is completely effective in the removal of enamel (alkyd resin base with a variety of pigments), epoxy, and polyamide coatings in combination with zinc chromate, water reducible, and epoxy primers. While methylene chloride is the major constituent responsible for quick loosening and release of the enamel paint films from the substrate, it can be concluded that the penetration of the epoxy and polyamide films is greatly affected by other constituents in the stripper. Two other strippers, Stripeeze and Kutzit, which contain significant amounts of methylene chloride together with cosolvents, were ineffective in removing both epoxy and polyamide coatings within the 20 minutes allowed in the test. The two missing ingredients were phenol and formic acid, both of which are solvents for polyamides. Formic acid also speeds the process by removing oxide films and breaking down the epoxies by hydrolyzing ether linkages.

MS-111 was completely effective in removing all of the aged coatings used in the test, including the Chemical Agent Resistant Coating (CARC), which is based on an aliphatic polyurethane material. Again, rapid penetration of the solvent to the substrate with attendant swelling of the film is considered to be the primary mechanism for lifting the polyurethane film.

Enthone Inc. (S-26)--

S-26 contains the same basic materials (methylene chloride, phenol, and formic acid) as MS-111, and they are in approximately the same proportions. The stripping mechanisms must therefore be similar for both strippers. The major differentiating characteristic of S-26 is its miscibility with water, which allows dilution to reduce the percentage of methylene chloride in the stripping bath. A small amount of an emulsifying agent is undoubtedly used in the formulation, although it is not specified in the MSDS. Emulsifying agents can also enhance the stripping action by accelerating the penetration of solvent into the paint film.

With the concentration of methylene chloride reduced, a slower stripping action might be expected. However, S-26 diluted with an equal volume of water (<25% methylene chloride) proved to be completely effective for removal of all coatings at the minimum submergence time of 20 minutes used in the test. Diluted S-26 was also as effective as MS-111 in the removal of old paint films including CARC (Appendix B). This performance attests to the basic power of methylene chloride as a paint stripper when supplemented by suitable cosolvents and activators.

Savogran Company (Stripeeze)--

Stripeeze contains four solvents; methylene chloride (<20%), methanol (<30%), toluene (<40%), and acetone (<25%). It is not obvious that any one of these would be considered as the main solvent in this formulation. Approximately 2% parafin wax is added as an evaporation retarder, probably because of the relatively higher volatility of toluene and acetone. No acids or other types of activator are listed in the MSDS.

Stripeeze was only effective in removing some of the enamel coatings used in the test. Even its effectiveness on enamel is apparently affected by the pigments used in the paint since only 70-80% of the white enamel was removed. The epoxy and polyamide coatings were virtually untouched even after 35 minutes submergence in the stripper.

Although methylene chloride is used as the basis for many epoxy strippers, acids are normally included as activators to increase the rate of stripping and to assist in breaking down and penetrating the epoxy film. It should also be noted that none of the cosolvents used in Stripeeze are identified in the literature as solvents for polyamides. Bench test results confirm the theoretically predicted performance in that this stripper was useful only for removal of the enamels among the paint types tested.

Savogran Company (Kutzit)--

Kutzit contains the same basic chemicals as Stripeeze roughly in equal proportions of <30% for each of the solvents. As in Stripeeze, about 2% parafin wax was added to retard evaporation of the more volatile solvents. Predictably, the performance of this stripper was similar to that of Stripeeze. Only enamels were removed in the bench test and close to 50% of the Code C enamel remained on the sample coupon after 20 minutes submergence in the stripper. The epoxy and polyamide coatings were not affected by this stripper.

Oakite Products, Inc. (ALM)--

ALM is an alkaline mixture (pH=13) of furfuryl alcohol (<10%), tributyl phosphate (<5%), monoethanolamine (10%), and sodium hydroxide (1%). Furfuryl alcohol is the major solvent in this formulation and tributyl phosphate is probably used as a cosolvent based on its ability to dissolve vinyls and nitrocellulosic materials. Monoethanolamine is a highly basic compound used with sodium hydroxide to produce the high pH of the solution.

It may also be used as an emulsifier and softener. The major stripping actions expected would be solvent penetration of a limited variety of coatings by furfuryl alcohol and tributyl phosphate, and caustic breakdown of an additional number of polymers when used at elevated temperatures.

The results of the bench scale test were consistent with what theory predicts. At room temperature ALM was partially effective in removing the enamels. The epoxy and polyamide coatings were unaffected. At elevated temperature the stripper was surprisingly effective in removing all of the enamels and the polyamides. Even at the higher temperature, the epoxy coating was essentially untouched.

When ALM was used at ambient temperature, partial removal of the enamels was probably accomplished through the solvent action of furfuryl alcohol and tributyl phosphate. At the elevated temperature, breakdown of these paint films was accelerated by the caustic. Failure of ALM to attack the epoxy coating even at elevated temperature was probably due to the lack of an effective solvent or organic acid in the stripper formulation. Both epoxy and polyamide are normally stable in aqueous caustic solutions. Although softening and hydrolysis of polyamides are possible mechanisms for the stripping action observed at the elevated temperature, it is likely that attack of the amide bond by monoethanolamine was an important factor in the performance of this stripper.

Oakite Products, Inc. (FHS)--

FHS contains butyl cellosolve (35%), diisobutyl ketone (10%), and mixed aromatic hydrocarbons (10%) as cosolvents. The formulation also includes formic acid (15%), dodecylbenzene sulfonic acid, and <5% hydrofluoric acid. On the basis of the variety of cosolvents and acids used in the formulation, FHS was considered to have high potential for effective stripping of the coatings used in the bench scale tests. Unfortunately, this was not the case.

The test results were mixed in that all of the enamel coatings were completely stripped and some of the polyamide coatings were removed, but the epoxy coatings were untouched. It is concluded that the combination of materials actually hindered the effectiveness of the formic acid as a solvent for polyamides and that the other solvents present were ineffective in lifting the epoxy film, even though acids were available to hydrolyze ether linkages in that film. The presence of strong acids, such as hydrofluoric and dodecylbenzene sulfonic acid, would tend to retard ionization of formic acid and thus interfere with ether cleavage. This stripper illustrates the degree of "art" involved in the formulation of effective strippers.

Gaf Corporation (M-PYROL 114064)

M-Pyrol is a trade name for n-methyl-2-pyrrolidone, an essentially pure compound (99.5%) used as an industrial solvent and chemical reaction medium, which has been proposed by the manufacturer for use in paint stripping formulations. No commercial paint strippers containing this chemical were identified during the conduct of this project. M-Pyrol was selected for testing in this project because it is not one of the chemicals included in the determination of TTO and the limited data available does not indicate that it is a hazardous chemical. It has proven capabilities as a solvent for a wide variety of polymers, including polyvinyls, polyamides, polyacrylics, cellulose derivatives, and fluorinated hydrocarbons. At least one patent has been issued for paint strippers based on the use of M-Pyrol.

The overall performance of M-Pyrol during the bench scale test was considered promising since all of the enamel films and over 50% of the epoxy coating were removed in the 35 minute stripping test. Its performance on polyamides was disappointing since it is a proven solvent for this material.

The only potential stripping mechanism for this chemical is solvent penetration of the paint film. There was no acid to attack ether linkages in epoxy films, or other activators to speed the stripping action. However, M-Pyrol was able to attack the epoxy coating. Following the test it was learned that hot M-Pyrol has been shown to be effective in stripping polyamide films. This would be expected since the film softens at higher temperatures, facilitating rapid penetration by the solvent. The stripping action for all paint films is apparently greatly accelerated when M-Pyrol is used at 65-82°C (150-180°F), and the high boiling point (202°C,395°F) makes this operation feasible without excessive loss of the solvent. Even partial removal of the epoxy coating during the test at room temperature was considered significant since two of the strippers containing methylene chloride without an acid, were completely ineffective on this coating.

Mitchell Bradford Chemical Company (Quick Strip #8)--

Quick Strip #8 contains methylene chloride (60%) and an undisclosed acid. Similar to MS-111, this stripper combines the solvent action of methylene chloride with an acid presumed to have the capacity for hydrolyzing the ether linkages in the epoxy film and for partial dissolution of the polyamides.

This formulation proved to be an effective stripper for all of the coatings used in the bench scale test and was also effective in removing the polyurethane coating (CARC) used on one of the aged paint samples. The stripping action was not as fast as that observed for MS-111 and S-26. This may have been due to the absence of phenol in the formula.

Nalco Chemical Company (84TB-227)--

The only information available for the 84TB-227 stripper indicates that it is composed of approximately 100% of an unidentified cyclic amide. The physical properties listed on the data sheet are similar to n-methyl-2-pyrrolidone, but the actually identity of the solvent could not be confirmed. Apparently the distributor of this stripper did not feel obligated to specifically identify the chemical used because it has not been designated as a health hazard or carcinogen.

The performance of 84TB-227 was similar to M-Pyrol in that nearly all of the enamel coatings were removed in the bench test. There was no degradation of the epoxy or polyamide coatings. It is not possible to speculate on the stripping mechanisms involved without additional information on the specific chemical(s) contained in the formulation.

Analysis of Physical Data

In addition to visual inspection, each of the sample coupons was weighed before and after the stripping operation. The before and after thickness of each coupon was also recorded (Appendix B). Although these data do not provide a precise measurement of stripping efficiency, they tend to support the conclusions reached through visual inspection. The average weight and thickness losses noted for all samples which were judged to be completely stripped of topcoat were essentially the same. Analysis of weight loss data also supports the assertion that Quick Strip No. 8, although equally as effective as MS-111 and S-26, is a slower acting stripper and could cause production delays if implemented at SAAD.

The amount of TTO discharged to the wastewater can also be affected by the viscosity or surface tension of the stripper. Strippers which exhibit poor drainage characteristics will increase the "dragout" from the strip tank and, therefore, the amount of stripper components which eventually find their way to the wastewater system. During the bench scale tests, careful measurements were taken to determine the amount of stripping solution lost. Oakite ALM, when used hot, showed a marked increase in "dragout". There was no detectable loss indicated for several of the non-methylene chloride strippers. The losses measured for MS-111, S-26(pure and diluted), Quick Strip 8, and Stripeeze were roughly the same (Appendix B).

Effect of Overall Characteristics of Stripper Formulations

Epoxy paints were known to be resistant to many organic solvents. This belief was confirmed by results showing that only strippers containing methylene chloride were completely effective in removing this coating. However, the strong resistance of the polyamide coatings to many of the strippers tested was not expected. The results were even more surprising since two of the ineffective strippers contained significant quantities of methylene chloride. Closer examination of the stripper formulations indicates that pH may have been the determining factor. All of the ineffective strippers had a neutral pH. ALM, an alkaline stripper, removed 100% of the polyamide topcoat in twenty minutes when heated to 82°C (180°), and the weight loss data was roughly equivalent to that obtained using MS-111. Acidic strippers were judged to be 100% effective in removing polyamide topcoats. Since ALM was not effective when used at ambient temperature, the temperature effect was probably more important than the alkaline pH.

Effect of Temperature on Stripper Performance

Oakite ALM was the only stripper initially recommended for use at an elevated temperature by the supplier. Its performance drastically improved for the removal of both enamel and polyamide top coats. Subsequent to completion of the test program the supplier of n-methyl-2-pyrrolidone (M-Pyrol) also recommended raising the temperature of this stripper to improve performance. If a higher operating temperature improved its effectiveness on epoxy, and a lower pH facilitated removal of the polyamide coating, the resultant stripper would be highly effective. Although this analysis may be over simplified, a new stripper formulation using of M-Pyrol has been recently patented and further development along these lines could be of significant benefit in pollution abatement efforts, based on the limited toxicity data available (Appendix D).

Effect of Substrate Material

Seven coating systems applied to aluminum panels were provided by SAAD for the bench scale tests. The eighth panel (Code H, TABLE 1.) was steel and it was coated with epoxy primer and polyamide topcoat, similar to one of the aluminum panels (Code E, TABLE 1.). Data from stripping tests indicate that substrate material had essentially no affect on the performance of any candidate stripper.

SUMMARY OF HAZARDOUS PROPERTIES OF STRIPPER CHEMICALS

An examination of the EPA Status Report of Chemical Activities indicates that most of the chemical compounds in the stripper formulations are currently under study because of their potential for harmful effects to health and the environment. Regulations governing their use have already been promulgated for many of these chemicals. Most of these compounds are also listed in Sax's "Dangerous Properties of Industrial Materials", 5th Edition. A qualitative characterization of each candidate stripper was developed on the basis of data available on the individual chemical components. These are presented in Appendix D. Table 5. contains a summary of the information obtained from a limited search of the available literature.

OVERALL EVALUATION AND RANKING OF ALTERNATIVE STRIPPERS

The final ranking of alternative strippers is dictated by the previously stated objectives of this project. Viable alternatives to MS-111 must be available on the commercial market and have demonstrated capability of removing all types of paint encountered in refurbishing equipment at the Sacramento Army Depot. Candidate strippers which satisfy these criteria must next be judged on their potential for eliminating or reducing the TTO in the wastewaters from the stripping process. Based on the concentration of methylene chloride and phenol,as reported on the MSDS or modified by the supplier, the three acceptable alternatives are ranked as follows:

1. Enthone S-26 diluted 1:1 with water......60% reduction in TTO
2. Mitchell-Bradford Quick Strip No.8.......33% reduction in TTO
3. Enthone S-26 (not diluted)...............22% reduction in TTO

TABLE 5. SUMMARY OF HAZARDOUS PROPERTIES OF CANDIDATE STRIPPERS

STRIPPER COMPOSITION	CARCINOGEN	MUTAGEN	TERATOGEN	IRRITANT	TWA OSHA	SELECTED EPA REGS
I Cyclic amide	-	-	-	-	-	-
II N-Methylpyrroldone	-	-	Indefinite (3) (4)	Skin (3)	-	-
III Methylene chloride 50%	Indefinite (3)	Yes (3)	Yes (3)	Yes (3)	500 ppm (3)	TTO (5) RCRA (2) CWA (2)
Phenol 20%	-	Yes (3)	Yes (3)	Yes (3)	5ppm (3)	TTO (5) CERCLA (2)
Formic acid 15%	-	Yes (3)	-	Yes (3)	5ppm (3)	RCRA (2) CERCLA (2)
IV Methylene chloride <20%	Indefinite (3)	Yes (3)	Yes (3)	Yes (3)	500 ppm (3)	TTO (5) RCRA (2) CWA (2)
Toluene <40%	Tumorigen (3)	Yes (3)	Yes (3)	Yes (3)	200 ppm(3)	TTO (5) TSCA (2)
Methanol <30%	-	Hi-(3) level	At high level(3)	Yes (3)	200 ppm(3)	RCRA (2) TSCA (2)
Acetone <25%	-	Hi-(3) level	At high level (3)	Yes (3)	1000 ppm(3)	RCRA (2) CERCLA (2)
V Methylene chloride <30%	Indefinite (3)	Yes (3)	Yes (3)	Yes (3)	500 ppm (3)	TTO (5) RCRA (2) CWA (2)
Toluene <30%	Tumorigen (3)	Yes (3)	Yes (3)	Yes (3)	200 ppm(3)	TTO (5) TSCA (2)
Methanol <30%	-	Hi-(3) level	At high level(3)	Yes (3)	200 ppm(3)	RCRA (2) TSCA (2)
Acetone <30%	-	Hi-(3) level	At high level (3)	Yes (3)	1000 ppm(3)	RCRA (2) CERCLA (2)
VI Methylene chloride 60%	Indefinite (3)	Yes (3)	Yes (3)	Yes (3)	500 ppm (3)	TTO (5) RCRA (2) CWA (2)
An acid	?	?	?	?	?	?
VII Methylene chloride 85%	Indefinite (3)	Yes (3)	Yes (3)	Yes (3)	500 ppm (3)	TTO (5) RCRA (2) CWA (2)
Phenol 10%	-	Yes (3)	Yes (3)	Yes (3)	5ppm (3)	TTO (5) CERCLA (2)
Formic acid 5%	-	Yes (3)	-	Yes (3)	5ppm (3)	RCRA (2) CERCLA (2)

TABLE 5. SUMMARY OF HAZARDOUS PROPERTIES OF CANDIDATE STRIPPERS
Continued

STRIPPER COMPOSITION	CARCINO-GEN	MUTA-GEN	TERATO-GEN	IRRI-TANT	TWA OSHA	SELECTED EPA REGS
VIII Monoethanol	-	-	-	Yes	3 ppm	CWA (2) TSCA (2)
Furfuryl alcohol <10%	-	Hi-(3) level	-	Yes (3)	50ppm (3)	CWA (2)
Tributyl phosphate <5%	-	-	At high level(3)	Yes (3)	5 mg/m^3 (3)	CWA (2) FIFRA (2)
Sodium hydroxide <1%	-	Yes (3)	-	Yes (3)	2 mg/m^3 (3)	FIFRA (2) CERCLA (2)
IX Butyl cellosolve 35%	-	-	Yes (3)	Yes (3)	50 ppm (3)	CWA (2) TSCA (2) FIFRA (2)
Formic acid 15%	-	Yes (3)	-	Yes (3)	5ppm (3)	RCRA (2) CERCLA (2)
Mixed aromatic hydrocarbons 10%	?	?	?	?	200 ppm (6)	?
Diisobutyl ketone 10%	-	-	-	Yes (3)	50(3) ppm	CWA (2)
Dodecylbenzene sulfonic acid ?	-	-	-	Yes (1)	-	CWA (2)
Hydrofluoric acid <5%	-	Yes (3)	Yes (3)	Yes (3)	3(3) ppm	RCRA (3) CERCLA (3)
X VIII at 180 degrees F.	See	above.				
XI III diluted 1:1	See	above.				

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APPENDIX A

TEST SPECIFICATIONS AND PROTOCOL

INTRODUCTION

Background

The refurbishing of materials and equipment at various military installations throughout the country is an activity that often contributes significantly to pollution control problems. Prior to the application of new surface finishes, all rust, oil, dirt, and old paint must be removed. In the case of equipment fabricated from aluminum, this is normally accomplished through the use of organic solvents, most of which contain compounds that are highly toxic. One of the most effective paint stripping compounds currently in use for this application is MS-111, a solvent containing about 10% phenols and up to 85% methylene chloride. This paint stripper contributes to the total toxic organic (TTO) loading in the waste waters discharged from the facility, creates potential air pollution problems, and leads to the possible formation of toxic or hazardous waste sludges in waste water treatment systems.

A number of commercial paint stripping formulations have been identified that contain chemicals that may be environmentally more acceptable than those contained in MS-111. While these formulations are considered to have the potential of performing the stripping operation as well as MS-111, data from systematic, controlled testing under comparable conditions is required to determine the true acceptability of these alternatives.

Objectives

The objectives of this test specification are to provide the bases for:

1. The development of the detailed test procedures to obtain the data necessary to fully evaluate and compare the performance of up to ten (10) alternative paint stripping formulations with that of MS-111 under carefully controlled conditions that are similar to those encountered in the equipment refurbishing activities at the Sacramento Army Depot (SAAD).

2. The design of equipment to carry out these bench scale testing procedures for the various alternative paint stripping formulations.

3. The development of a complete cost proposal for the procurement of all required equipment and materials, and performance of the prescribed testing.

SCOPE OF WORK

Development of Test Procedures

Based on the following supporting information and the functional requirements of the testing, the contractor shall develop detailed step by step test procedures for submittal in the proposal.

Process Description - Sacramento Army Depot--

The cold stripping operation at the SAAD is used primarily for the removal of paint from various structural aluminum components that have been dis-assembled and removed from the equipment to be refurbished. These components may be passed through a degreasing step prior to the stripping operation when conditions warrant. The dry, degreased items are then stacked into a perforated basket for submergence into the stripping solution. The normal submergence time is 15-20 minutes. The perforated basket is then raised above the solution tank and allowed to drain until most of the free liquid has been discharged back into the stripping tank. The basket is next submerged for approximately one (1) minute in a hot caustic solution to further loosen the paint film and to neutralize any acid remaining from the cold stripping bath. After removal of the basket from the caustic solution and completion of a draining operation, the basket is submerged in fresh water for a final rinse.

After the basket has been removed from the fresh water rinse tank individual items are removed and hand cleaned with a steam/hot water lance for removal of all traces of loose paint film. At this point the components are visually inspected. The presence of significant amounts of the original primer coat is considered acceptable, but items that still have adherent top coat films are returned to the stripping operation. All items which pass this visual inspection are sent on to the sand blasting shop where the surface is completely cleaned and prepared to receive a new chromate primer coat.

Functional requirements of the Bench Scale Testing --

Test procedures are to be developed to simulate the process described above for the steps involving cold stripping, hot caustic wash/neutralization, fresh water rinsing, and steam/hot water lancing. The scope of the testing will be that required to:

- Establish a base line for evaluation by processing a set of samples through the bench scale stripping operation using MS-111 and evaluating the surface condition resulting for submergence times of 10, 20, and 30 minutes.

- Evaluate the surface condition resulting from the processing of samples through the stripping operation using each of the candidate stripping formulations and compare the results with those obtained using MS-111 for each of the three submergence times.

- Evaluate the surface condition resulting from the processing of samples with 'aged' coatings through the stripping operation using MS-111 and the three most promising stripping formulations as recommended by the contractor and approved by CARLTECH.

In addition to visual inspection of test pieces following the stripping operation, the proposer should recommend any surface testing or other means which might prove useful in evaluating the effectiveness of the individual stripping formulations. As a minimum the sample coupons should be examined and photographed at 10X magnification.

Design of Test Apparatus

Except as noted below the proposer is to provide all equipment and materials necessary to carry out the bench scale test program. Tanks and other equipment used for the cold stripping and hot caustic baths must be constructed of materials suitable for the handling of these hazardous liquids. The test apparatus must be installed so that adequate ventilation is provided for the protection of the personnel conducting the tests.

The following material will be provided by CARLTECH:

1. Sheet aluminum panels (approximately 3'x3') coated in accordance with various military paint specifications. These panels will serve as stock material for the preparation of coupon samples.

2. The paint specifications for each aluminum panel provided above.

3. A complete list (maximum of ten) of all commercial paint stripping formulations to be used in the bench scale tests.

4. Material Safety Data Sheets and/or the complete chemical formulation of all candidate paint strippers.

5. An adequate supply of aluminum components with 'aged' coatings for final testing of the most promising strippers.

The contractor shall provide for the following:

1. The design and fabrication or procurement of all required tanks, vessels and materials handling equipment.

2. The design and preparation of all required coupon samples.

3. The design and fabrication of sample holders for submersion of samples in the process tanks.

4. The provision of equipment and/or instrumentation proposed for evaluation of the surface condition of samples following the stripping tests.

5. The timely procurement of an adequate quantity of all candidate paint stripping formulations to be used in the tests.

6. Photographic equipment suitable for producing pictures of samples at 10x magnification.

Utility Requirments

In order to conduct the bench scale testing in a safe and effective manner, the contractor's facility must provide:

1. Ventilation equipment adequate to handle any noxious fumes or vapors that may evolve from the organic stripping baths and caustic wash.

2. A steam/hot water lance supplied with saturated steam or hot water at a temperature of at least 220 degrees Fahrenheit.

3. Steam or electric heating capacity to maintain the caustic bath at a temperature of approximately 180 degrees Fahrenheit.

4. A satisfactory system for handling spills and accidental discharges.

5. Adequate protective clothing and safety equipment for personnel performing the test.

Analytical Requirments

Although a major objective of this program is to identify an acceptable cold stripper for aluminum that will reduce the environmental hazards involved in the operation, it is unlikely that any meaningful quantitative information on potential pollution levels can be obtained from the bench scale tests. Therefore, no requirement for analysis of the stripping baths or rinse waters from the process is anticipated. However, proposers should provide a complete description of their analytical capabilities as an aid in evaluating the flexibility available to meet changing requirements that may develop during the testing.

Reporting Requirements

1. Weekly progress reports should be sent to CARLTECH. The report should be brief and provide a concise description of the status of the test program along with a statement of the work scheduled for the following week. The contractor may use any format considered appropriate.

2. A final technical report will be submitted within ten (10) working days following the completion of all testing. This report will contain an evaluation of the performance of all stripping formulations used in the test program, a ranking of all strippers from the most effective to the least effective, normal size and magnified photographic documentation of the surface condition of all sample coupons used in the test and data obtained from any

additional testing of sample surface conditions that may be proposed by the contractor and approved for use in the test program by CARLTECH.

3. The contractor must agree to provide access to CARLTECH employees and other concerned parties as designated by CARLTECH for observation of the stripping tests and at other reasonable times during normal working hours as mutually agreed for discussions to resolve any problems that may arise during the test program.

QUALITY ASSURANCE

It is the policy of CARLTECH to produce engineering and scientific studies of the highest caliber. In keeping with the corporate goal of excellence the management of CARLTECH has made a commitment to the quality assurance goals of the Environmental Protection Agency. All reported data will be accompanied by calculations of precision and accuracy, and information on completeness, representativeness and comparability will be supplied as appropriate.

COST PROPOSAL

It is the intention of CARLTECH to negotiate a firm fixed price contract for the work described in this test specification. Since the exact number of paint stripping formulations to be tested is not known at the time of this solicitation, the cost proposal should be presented in two parts as follows:

- A firm fixed price must be proposed for the design, fabrication, procurement and installation of all equipment, materials, and supplies required to carry out the bench scale test program.

- A firm fixed unit price must be proposed for the complete testing, data analysis, and sample evaluation of a single stripping formulation. This unit price will not include the cost of procuring the specified stripping formulation, since the final selections of strippers will not be made until just prior to contract award and the allowable cost will be negotiated at that time.

It should be noted that any item of equipment which must be purchased specifically for the performance of work under this contract, the price of which is charged to this contract, will become the property of CARLTECH, and its disposition at the end of the contract will be determined by CARLTECH.

SELECTION CRITERIA

The following criteria will be used in selecting a contractor for this work:

A. Willingness to follow all contractual obligations as outlined in this solicitation;

B. Immediate availability of facilities adequate for performance of the specified tests;

C. Curriculum vitae and capabilities of the personnel proposed;

D. Record of performance on similar projects;

E. An evaluation of the probable total cost for the project based on the contractor's proposal; and

F. The availability of backup analytical capabilities at the test site.

Date October 1, 1985
Modified October 15, 1985,
See Section G

Doc. No. IMC 10185A
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Industrial Maintenance Corporation

LABORATORY DIVISION

EVALUATION OF ALTERNATIVES TO TOXIC ORGANIC PAINT STRIPPER BENCH SCALE TEST

A. Objectives of Bench Scale Testing

Evaluate paint stripping ability of commercially available stripping formulations relative to MS-111 using coupons cut from coated panels. Evaluation to be conducted using carefully controlled conditions that are similar to the cold stripping, cold caustic wash/neutralization, fresh water rinsing, and steam/hot water lancing process currently being used. After stripping, coupons will be visually inspected and photographed. Strippers will be evaluated and ranked from most effective to least effective. The three (3) most promising strippers plus MS-111 will be used to evaluate coupons from panels with aged coatings.

Coupons 1" x 4" will be cut from 11½" x 11½" panels as described in Table IA

Table IA Panel Description

Code	Color	Material	Primer	Top Coat
A	light gray	Aluminum	Zinc	Enamel
B	dark gray	Aluminum	Zinc Chromate	Enamel
C	white	Aluminum	Zinc Chromate	Enamel
D	cream	Aluminum	Primer	Epoxy
E	black	Aluminum	Epoxy	Polyamide
F	black	Aluminum	Water Reduceable	Polyamide
G	black	Aluminum	Zinc Chromate	Polyamide
H	black	Steel	Epoxy	Polyamide

Author

Approved John T. Coene

Signature Wilfred J. Hahn
Keltech Associates Inc

Stripping formulations to be evaluated are described in Table IIA

Table IIA Stripping Formulations

Code	Description	Supplier
I	84TB-227	Nalco Chemical Company
II	140641	Diversy-Wyandotte or GAF
III	S-26	Enthone, Inc.
IV	Stripeeze	Savogran Company
V	Kutzit	Savogran Company
VI	Quick Strip No. 8	Mitchell-Bradford Chem. Co.
VII	MS-111	Miller-Stephenson Chem. Co.
VIII	ALM	Oakite

Hangers will be constructed to hold eight (8) coupons for the purpose of dipping coupons in stripper solutions using dipping times described in Table IIIA.

Table IIIA Dipping Times

Code	Minutes
20	20
35	35

Author

Signature Wilfred J Hale

Approved John T. Corney

B. Additional Equipment and Supplies

1. Band saw for cutting coupons
2. Drill press
3. A steam/hot water lance capable of operation at approximately 220°F.
4. Thermometer
5. Laboratory timmers
6. Stainless steel beakers, capable of holding approximately 2 gallons.
7. Desiccator
8. Analytical balance capable of weighing 0.1 mg.
9. A 5 gallon pail
10. Photographic equipment to provide 1x and 7x photographs of coupons.
11. Hangers constructed of stainless steel capable of holding eight (8) coupons.
12. Several gallons of 50% caustic.
13. Ventilation fans
14. Graduated cylinders capable of holding four (4) liters.
15. A micrometer capable of measuring 0.001 inch.
16. A rack to hold coupons for steam/hot water cleaning.
17. Supports for suspending hangers in stripping solution.

C. Coupon Preparation

1. Cut 1" x 4" coupons from each 11½" x 11½" panel utilizing existing holes in panels.
2. Examine each coupon for paint chipping along cut edge - reject coupons with serious chipping.
3. Using vibra tool mark established codes for:
    1. panel description from Table IA
    2. stripper description from Table IIA
    3. dipping time from Table IIIA on the back of each coupon.
4. Measure thickness of each coupon with a micrometer to the closest thousandth (0.001) of an inch and record as initial thickness.
5. Wipe each coupon clean with lint free cloth - if appreciable amount of oil/grease, use cloth moistened with alcohol.
6. After cleaning, place coupons in desiccator, using forceps, for at least one (1) hour.

Author ______ **Approved** John T. Carney

Signature ______

7. Using forceps, quickly transfer coupon to analytical balance and weigh to closest 0.1 mg within a 2 minute period. Record coupon weight as initial weight and return coupon to desiccator for storage.

D. Stripping Procedure

Before starting stripping procedure, be sure adequate exhaust ventilation has been established.

1. Fill a 5 gallon pail approximately ½ full with tap water.
2. Using a 4L graduated cylinder, measure approximately 3.5L of 50% caustic then transfer to a S.S. beaker and cover with a lid. Record volume of caustic.
3. Using a 4L graduated cylinder, measure 3.5L of stripper to be evaluated then transfer to S. S. beaker and cover with lid. Repeat for each dipping time to be used. Record volume(s) of stripper as initial volume.
4. Place one (1) coupon from each panel on specially constructed S.S. hanger(s) suspended above each beaker of stripping solution.
5. Record ambient temperature.
6. Lower hanger(s) into stripper, completely submerging coupons, and start timer(s) which have been set to dipping times as described in Table IIIA. Keep stripping solution(s) covered during stripping process.
7. At end of dipping time(s) remove hanger(s) from stripping solutio and allow coupons to drain briefly.
8. Transfer hanger(s) containing coupons to 50% caustic solution using two (2) very brief in and out dippings.
9. Immediately transfer hanger(s) containing coupons to fresh water container and rinse using several repeated dippings.
   NOTE: It is important to be repetitive and consistant during caustic and fresh water rinsing steps as caustic will attack aluminum coupons.
10. After fresh water rinse, remove coupons from hanger(s) and place on rack for steam/hot water cleaning.
11. Using steam/hot water lance, maintained at approximately 220°F, completely remove any traces of loose paint film from all surfaces of coupon(s).

Author

Approved

Signature

12. Record any pertinent observations during the stripping process and make note of initial observation as to effectiveness of paint removal.
13. Be sure coupons are completely dry by pat-drying with clean lint free cloth, then using forceps, quickly place coupons in desiccator, evacuate, and store for at least two (2) hours.
14. After stripping process is complete, transfer stripping solution from each beaker into a 4L graduated cylinder and record volume as final volume.
15. Allow enough time for any solid material to settle to bottom of cylinder then decant only clear stripper into original shipping container. Discard any stripper containing residue material in appropriate waste container.
16. Thoroughly wash all containers and equipment before reusing - steam/hot water lance can be used.

E. Coupon Evaluation After Stripping

1. After at least two (2) hours in desiccator, transfer coupon(s), using forceps, to analytical balance and weigh to closest 0.1 mg within a two (2) minute period. Record weight as final weight.

2. Measure the thickness of a representative area (type of surface covering the greatest area) on each coupon, with a micrometer, to the closest thousandth (0.001) of an inch and record as final thickness.

3. Visually inspect each coupon for effectiveness of stripping and record observations based on the following:
   (a) Percent (%) of top coat and/or primer removed.
   (b) Distribution of remaining top coat and/or primer expressed as localized, uniform, or random.
   (c) Any pertinent observation pertaining to top coat and/or primer remaining after stripping process.

   NOTE: A grid placed over coupon divided into twenty (20) equal areas, each representing 5% of the total surface area, may be used to determine % of top coat and/or primer removed.

Author

Approved

Signature

4. Photograph Coupons

   (a) Photograph each coupon using a 1x camera.
   (b) Photograph selected area on coupons using a 7x camera. Selected area will be one with top coat and/or primer remaining.
   (c) Label all photographs with coupon code.

5. Evaluate the surface condition resulting from the processing of samples through the stripping operation using each of the candidate stripping formulations and compare the results with those obtained using MS-111.

6. Based on recorded information, visual observations, and evaluations, all stripping formulations will be ranked from the most effective to the least effective.

F. Stripping Process Using Coupons From Aged Panels

1. Evaluate the surface condition resulting from the processing of samples with "aged" coatings through the stripping process using MS-111 and the two (2) or three (3) most promising stripping formulations as recommended by the contractor and approved by CARLTECH.

   Coupon preparation and stripping process used for "aged" coatings will be as described in Sections C and D.

Author

Approved

Signature

G. Modification

1. After initial bench testing was conducted, three (3) additional strippers were evaluated as indicated by codes IX, X and XI in Table IIB.

Table IIB Stripping Formulations

Code	Description	Supplier
I	84TB-227	Nalco Chemical Company
II	140641	GAF
III	S-26	Enthone, Inc.
IV	Stripeeze	Savogran Company
V	Kutzit	Savogran Company
VI	Quick Strip No. 8	Mitchell-Bradford Chem. Co.
VII	MS-111	Miller-Stephenson Chem. Co.
VIII	ALM (at room temperature)	Oakite
IX	FHS	Oakite
X	ALM (at 180°F)	Oakite
XI	S-26 (diluted 1:1 with water)	Oakite

2. Coupon Preparation For Additional Stripping Formulations

Coupons from original panels measuring 1" x 3½" were used to evaluate strippers IX, X, and XI as all available 1" x 4" coupons were used to conduct previous evaluations.

3. Stripping Procedure and Coupon Evaluation

With the exception of evaluating stripping formulation X (ALM) at 180°F, all other aspects of the stripping procedure and coupon evaluation were followed as written.

Author

Approved John T. Cooney

Signature

Date October 15, 1985 - Modification **Doc. No.** IMC 10185A

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Industrial Maintenance Corporation

LABORATORY DIVISION

4. "Aged" Coupons

Received four (4) sets of three (3) coupons each, with "aged" coatings as described in Table IVA. The following aluminum coupons have been "irridated".

Table IVA Coupons With "Aged" Coatings

Code	Description
4	
5	Water reducible epoxy primer. MIL-P-53030
6	
8	Water base primer - MIL-P-53030. With
9	Coupon Epoxy top coat (no Mil Spec) made
10	by tap plastics.
12	Water base primer (Mil-P-53030), CARC
13	top coat (Mil-C-46168).
14	
16	Water base primer (MIL-P-53030). With
17	Forest Green enamel. Top Coat (MIL-E-52798).
18	

5. Preparation Of "Aged" Coupons

Coupons only required drilling a hole for purpose of hanging during dipping. Coupon measured approximately 1" x 2 5/8".

6. Stripping Procedure and Coupon Evaluation Using "Aged" Coatings

With the exception of using only a 35 minute dipping time, all other aspects of the stripping procedure and coupon evaluation were followed as previously written.

Author Approved

Signature

APPENDIX B

SUBCONTRACTOR REPORT

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I. Raw Data Sheets

II. Photographs

1.0 INTRODUCTION

In September, 1985 IMCOR signed a contract with CARLTECH to evaluate several commercial paint stripping formulations and compare the results to those obtained when using MS-111, the formulation currently used at various military installations. MS-111 contains up to 85% Methylene chloride and contributes to the TTO loading in the waste waters discharged, creates potential air pollution problems, and leads to the possible formation of toxic or hazardous waste sludges in waste water treatment systems.

A number of commercial paint stripping formulations were identified that contain chemicals that are environmentally more acceptable than those in MS-111. This report describes the testing and evaluation of these strippers and compares the results to those obtained with MS-111.

2.0 SUMMARY

A contract between CARLTECH and IMCOR was signed on 5 September 1985. Ordering of strippers and necessary equipment for the testing was begun immediately. Actual set-up of the test area was accomplished on September 13 and September 16, 1985. Testing was begun on October 9 and completed on October 17, 1985. Some difficulty was incurred in getting the strippers, particularly the stripper from Diversy-Wyandotte. A total of nine strippers were tested. One (1) of these strippers, S-26, was also tested at 1:1 dilution and another, Oakite ALM, at 180°F in addition to the standard testing.

Coupons measuring 1" x 4" were prepared in the facility's machine shop using samples submitted by the Sacramento Army Depot. The samples were of eight (8) different top coat and primer preparations on aluminum for seven samples and steel for one. The top three (3) strippers as determined by testing were selected and tested on aged samples provided by CARLTECH from Sacramento.

All samples were photographed after stripping. Group, 1:1, and 7x area magnification photos were made. The group and 1:1 photos are more beneficial for observation.

Based on results of the testing and visual observation, the three (3) best strippers were MS-111, S-26, and Quick Strip #8. S-26 performed as well in 1:1 dilution.

3.0 TEST PROCEDURE

3.1 Objectives

Evaluate paint stripping ability of commercially available stripping formulations relative to MS-111 using coupons cut from coated panels. Evaluation to be conducted using carefully controlled conditions that are similar to the cold stripping, cold caustic wash/neutralization, fresh water rinsing, and steam/hot water lancing process currently being used. After stripping, coupons were visually inspected and photographed. Strippers were evaluated and ranked from most effective to least effective. The two (2) most promising strippers plus MS-111 were used to evaluate coupons from panels with aged coatings.

Coupons 1" x 4" were cut from 11¼" x 11¼" panels as described in Table I, except for "aged" coatings where 1" x 3¼" coupons provided were used as described in Table II.

Table I Panel Description

Code	Color	Material	Primer	Top Coat
A	light gray	Aluminum	Zinc	Enamel
B	dark gray	Aluminum	Zinc Chromate	Enamel
C	white	Aluminum	Zinc Chromate	Enamel
D	cream	Aluminum	Primer	Epoxy
E	black	Aluminum	Epoxy	Polyamide
F	black	Aluminum	Water Reducible	Polyamide
G	black	Aluminum	Zinc Chromate	Polyamide
H	black	Steel	Epoxy	Polyamide

Table II Coupons With "Aged" Coatings

Code	Description
4	Water reducible epoxy primer. MIL-P-53030
5	
6	
8	Water base primer - MIL-P-53030. With Coupon Epoxy top coat (no Mil Spec) made by tap plastics.
9	
10	
12	Water base primer (Mil-P-53030), CARC top coat (Mil-C-46168).
13	
14	
16	Water base primer (MIL-P-53030). With Forest Green enamel. Top Coat (MIL-E-52798).
17	
18	

Stripping formulations evaluated are described in Table III

Table III Stripping Formulations

Code	Description	Supplier
I	84TB-227	Nalco Chemical Company
II	140641	GAF
III	S-26	Enthone, Inc.
IV	Stripeeze	Savogran Company
V	Kutzit	Savogran Company
VI	Quick Strip No. 8	Mitchell-Bradford Chem. Co.
VII	MS-111	Miller-Stephenson Chem. Co.
VIII	ALM (at room temperature)	Oakite
IX	FHS	Oakite
X	ALM (at 180°F)	Oakite
XI	S-26 (diluted 1:1 with water)	Enthone, Inc.

Hangers were constructed to hold eight (8) coupons for the purpose of dipping coupons in stripper solutions using dipping times described in Tab[illegible]

Table IV Dipping Times

Code	Minutes
20	20
35	35

Only 35 minute dipping time was used for "aged" coatings.

3.2 Equipment and Supplies

A. Band saw for cutting coupons

B. Drill press

C. A steam/hot water lance capable of operation at approximately 220°F.

D. Thermometer

E. Laboratory timers

F. Stainless steel beakers, capable of holding approximately 2 gallons.

G. Desiccator

H. Analytical balance capable of weighing 0.1 mg.

I. A 5 gallon pail

J. Photographic equipment to provide 1x and 7x photographs of coupons.

K. Hangers constructed of stainless steel capable of holding eight (8) coupons. (See Drawing #1).

L. Several gallons of 50% caustic.

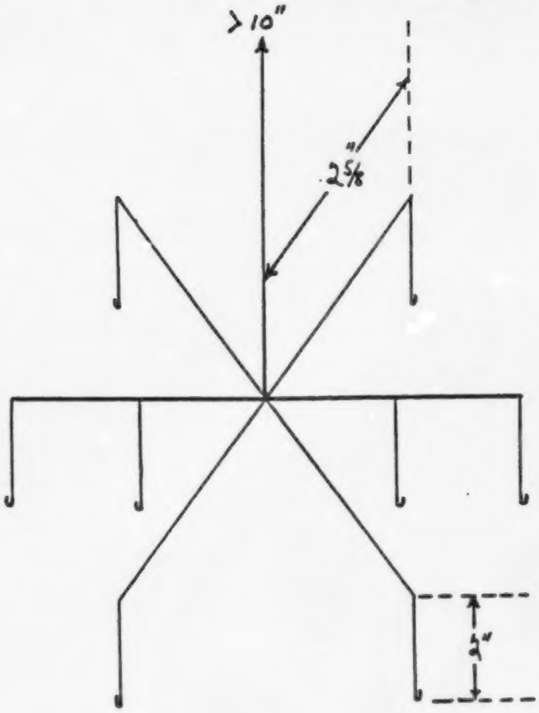
M. Ventilation fans

N. Graduated cylinders capable of holding four (4) liters.

O. A micrometer capable of measuring 0.001 inch.

DRAWING 1

Stainless Steel Hanger For Coupons



P. A rack to hold coupons for steam/hot water cleaning.

Q. Supports for suspending hangers in stripping solution.

3.3 Coupon Preparation

A. Cut 1" x 4" coupons from each 11½" x 11½" panel utilizing existing holes in panels. (See Drawing #2).

B. Examine each coupon for paint chipping along cut edge - reject coupons with serious chipping.

C. Using vibra tool, mark established codes for:

1. panel description from Tables I and II

2. stripper description from Table III

3. dipping time from Table IV on the back of each coupon.

D. Measure thickness of each coupon with a micrometer to the closest thousandth (0.001) of an inch and record as initial thickness.

E. Wipe each coupon clean with lint free cloth - if appreciable amount of oil/grease, use cloth moistened with alcohol.

F. After cleaning, place coupons in desiccator, using forceps, for at least one (1) hour.

G. Using forceps, quickly transfer coupon to analytical balance and weigh to closest 0.1 mg within a 2 minute period. Record coupon weight as initial weight and return coupon to desiccator for storage.

3.4 Stripping Procedure

Before starting stripping procedure, be sure adequate exhaust ventilation has been established.

A. Fill a 5 gallon pail approximately ½ full with tap water.

B. Using a 4L graduated cylinder, measure approximately 3.5L of 50% caustic then transfer to a S.S. beaker and cover with a lid. Record volume of caustic.

C. Using a 4L graduated cylinder, measure 3.5L of stripper to be evaluated then transfer to S.S. beaker and cover with lid.
Repeat for each dipping time to be used. Record volume(s) of stripper as initial volume.

D. Place one (1) coupon from each panel on specially constructed S.S. hanger(s) suspended above each beaker of stripping solution.

E. Record ambient temperature.

F. Lower hanger(s) into stripper, completely submerging coupons, and start timer(s) which have been set to dipping times as described in Table IV. Keep stripping solution(s) covered during stripping process.

G. At end of dipping time(s) remove hanger(s) from stripping solution and allow coupons to drain briefly.

H. Transfer hanger(s) containing coupons to 50% caustic solution using two (2) very brief in and out dippings.

I. Immediately transfer hanger(s) containing coupons to fresh water container and rinse using several repeated dippings.
NOTE: It is important to be repetitive and consistent during caustic and fresh water rinsing steps as caustic will attack aluminum coupons.

J. After fresh water rinse, remove coupons from hanger(s) and place on rack for steam/hot water cleaning.

K. Using steam/hot water lance, maintained at approximately 220°F, completely remove any traces of loose paint film from all surfaces of coupon(s).

L. Record any pertinent observations during the stripping process and make note of initial observation as to effectiveness of paint removal.

M. Be sure coupons are completely dry by pat-drying with clean lint free cloth, then using forceps, quickly place coupons in desiccator, evacuate, and store for at least two (2) hours.

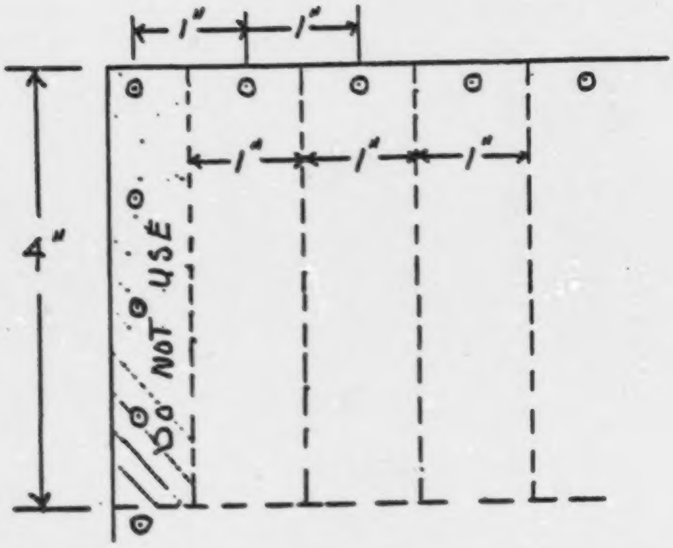
N. After stripping process is complete, transfer stripping solution from each beaker into a 4L graduated cylinder and record volume as final volume.

O. Allow enough time for any solid material to settle to bottom of cylinder then decant only clear stripper into original shipping container. Discard any stripper containing residue material in appropriate waste container.

P. Thoroughly wash all containers and equipment before reusing - steam/hot water lance can be used.

DRAWING 2

Coupon Preparation From 11¼" x 11¼" Panels


1"
1"
1"
1"
1"
4"
DO NOT USE

3.5 Coupon Evaluation

A. After at least two (2) hours in desiccator, transfer coupon(s), using forceps, to analytical balance and weight to closest 0.1 mg within a two (2) minute period. Record weight as final weight.

B. Measure the thickness of a representative area (type of surface covering the greatest area) on each coupon, with a micrometer, to the closest thousandth (0.001) of an inch and record as final thickness.

C. Visually inspect each coupon for effectiveness of stripping and record observations based on the following:

   (1) Percent (%) of top coat and/or primer removed.

   (2) Distribution of remaining top coat and/or primer expressed as localized, uniform, or random.

   (3) Any pertinent observation pertaining to top coat and/or primer remaining after stripping process.

   NOTE: A grid placed over coupon divided into twenty (2) equal areas, each representing 5% of the total surface area, may be used to determine % of top coat and/or primer removed.

D. Photograph Coupons

   (1) Photograph each coupon using a 1x camera.

   (2) Photograph selected area on coupons using a 7x camera. Selected area is one with top coat and/or primer remaining.

   (3) Label all photographs with coupon code.

E. Evaluate the surface condition resulting from the processing of samples through the stripping operation using each of the candidate stripping formulations and compare the results with those obtained using MS-111.

F. Based on recorded information, visual observations, and evaluations, all stripping formulations were ranked from the most effective to the least effective.

3.6 Stripping Process Using Coupons From Aged Panels

Evaluate the surface condition resulting from the processing of samples with "aged" coatings through the stripping process using MS-111 and the two (2) most promising stripping formulations as recommended by the contractor and approved by CARLTECH.

4.0 DISCUSSION

The contract between CARLTECH and IMCOR was signed on September 5, 1985. The building on Pad #12 at the Wrightsville Beach Test Facility was selected for the testing because it provided excellent ventilation. Set-up of the test area was completed in September. Trial runs with MS-111 were begun on October 3, 1985 using coupons prepared from samples received from the Sacramento Army Depot. All stripper formulations were received by October 10, 1985. Aged coupons were hand delivered by CARLTECH on October 10, 1985. Testing of the stripping formulations was completed on October 17, 1985. The remaining evaluation including photographing of the coupons was completed on October 29, 1985.

As part of the coupon evaluation, weight loss was determined from initial coupon weights and weights after stripping procedure. Coupons were also evaluated visually and photographed. Photographs taken of each coupon were 1:1 and a 7x magnification of a typical area of the coupon. A group color photo of coupons for each stripper, after stripping procedure, was also taken.

Mr. W. J. Hahn, CARLTECH, visited the facility on September 24, 1985 to observe the initial set-up of the test area and to discuss the test procedure and modifications to the contract. Mr. Dewey Dykstra, CARLTECH, and a representative of EPA visited the facility on October 10, 1985. They delivered the aged coupons and observed the actual stripping procedure.

Results of testing the stripper formulations on the original coupons were communicated to CARLTECH personnel by telephone. Mr. Dykstra observed some of the results during his visit to the facility. Based on these discussions, the two (2) best candidate strippers were selected to test on the aged coupons. It was further agreed that the third most effective candidate stripper would not be tested on the aged coupons because it was not effective on the panel with epoxy top coat.

Evaluation of primer removal for each coupon was not done since the color of the primer was not known. Therefore, any changes it would undergo in the stripping process could not be evaluated.

The effect of caustic on the original (aluminum) panels was evident. When most of the top coat and primer were removed in the stripper, apparently the caustic did attack the bare metal as evidenced by the metal's bright, shiny appearance.

5.0 RESULTS

Percent weight loss (gain), thickness loss (gain), and percent top coat removal are given in the following tables for each stripper. Results are shown for each coupon sample at 20 and 35 minutes time in the stripping formulation. Comments are given below each table.

Aged coupons were tested using MS-111 plus the two (2) strippers that gave the best results. Time in the stripping formulation for the aged coupons was 35 minutes.

Table V in this section gives the percent weight loss for each coupon by stripper formulation. Table VI gives the average weight loss of all coupons for each stripper. Table VII gives the average weight loss for aged coupons using MS-111 and the two (2) best candidate strippers. A definite relation between weight loss and visual observation of paint removed can be seen.

Table VIII shows volume loss of strippers during the stripping procedure.

Raw data sheets are located in Appendix I. Observations and comments are listed on these sheets.

STRIPPER: NALCO 84TB227 DATE: 10-9-85

Coupon Code #	% Weight Loss	Thickness Loss In Inches	% Top Coat Removal
A-I-20	2.53	0.002	100
A-I-35	2.70	0.002	100
B-I-20	1.21	0.001	100
B-I-35	1.75	0.001	100
C-I-20	2.86	0.001	20
C-I-35	3.98	0.002	95
D-I-20	-0.39 *	0.000	0
D-I-35	-0.63 *	0.001	0
E-I-20	-0.21 *	0.001	0
E-I-35	-0.16 *	0.000	0
F-I-20	-0.19 *	0.000	0
F-I-35	-0.15 *	0.000	0
G-I-20	-0.25 *	0.000	0
G-I-35	-0.21 *	0.000	0
H-I-20	-0.39 *	0.000	0
H-I-35	0.34	0.000	0

20 minutes - top coat removed only on first and second coupons. Partially removed on third coupon

35 minutes - same

Primer partially removed on first and second coupons.

* Weight gain observed for coupons with zero (0) to minimal removal of top coat attributed to stripper and/or caustic trapped during stripping process.

STRIPPER: M-PYROL **DATE:** 10-10-85

Coupon Code #	% Weight Loss	Thickness Loss In Inches	% Top Coat Removal
A-II-20	2.68	0.001	100
A-II-35	2.99	0.002	100
B-II-20	1.39	0.001	100
B-II-35	1.43	0.001	100
C-II-20	2.58	0.001	50
C-II-35	3.86	0.002	90
D-II-20	-0.79 *	0.000	0
D-II-35	4.55	0.004	55
E-II-20	-0.24 *	0.000	0
E-II-35	-0.28 *	0.000	0
F-II-20	-0.26 *	0.000	0
F-II-35	-0.23 *	0.000	0
G-II-20	-0.33 *	0.000	0
G-II-35	-0.20 *	0.000	0
H-II-20	-0.04 *	0.000	0
H-II-35	-0.009 *	0.000	0

20 minutes - top coat removed on first and second coupons. Primer partially removed on first and second coupons.

35 minutes - top coat removed on first and second coupons and partially removed on third and fourth. Primer partially removed on first and second coupons.

* Weight gain observed for coupons with zero (0) to minimal removal of top coat attributed to stripper and/or caustic trapped during stripping process.

STRIPPER: ENTHONE S-26 DATE: 10-9-85

Coupon Code #	% Weight Loss	Thickness Loss In Inches	% Top Coat Removal
A-III-20	3.09	0.002	100
A-III-35	3.55	0.002	100
B-III-20	2.43	0.001	100
B-III-35	2.39	0.001	100
C-III-20	4.83	0.002	100
C-III-35	4.88	0.002	100
D-III-20	9.86	0.005	100
D-III-35	9.87	0.005	100
E-III-20	4.12	0.002	100
E-III-35	4.04	0.002	100
F-III-20	3.95	0.002	100
F-III-35	4.46	0.002	100
G-III-20	4.14	0.002	100
G-III-35	3.94	0.002	100
H-III-20	0.68	0.001	100
H-III-35	6.74	0.001	100

20 minutes - top coat and primer removed on all coupons.

35 minutes - top coat and primer removed on all coupons.

STRIPPER: STRIPEEZE **DATE:** 10-10-85

Coupon Code #	% Weight Loss	Thickness Loss In Inches	% Top Coat Removal
A-IV-20	2.86	0.002	100
A-IV-35	2.85	0.002	100
B-IV-20	1.41	0.001	100
B-IV-35	1.46	0.001	100
C-IV-20	3.44	0.001	75
C-IV-35	3.78	0.002	85
D-IV-20	-0.07 *	0.000	0
D-IV-35	-0.04 *	0.000	0
E-IV-20	0.02	0.000	0
E-IV-35	0.04	0.000	0
F-IV-20	0.02	0.000	0
F-IV-35	0.05	0.000	0
G-IV-20	0.03	0.000	0
G-IV-35	0.04	0.000	0
H-IV-20	-0.01 *	0.000	0
H-IV-35	-0.01 *	0.000	0

20 minutes - top coat removed on first and second coupons, partially on third. Some primer removed on first and second.

35 minutes - Same as above.

* Weight gain observed for coupons with zero (0) to minimal removal of top coat attributed to stripper and/or caustic trapped during stripping process.

STRIPPER: KUTZIT **DATE:** 10-9-85

Coupon Code #	% Weight Loss	Thickness Loss In Inches	% Top Coat Removal
A-V-20	2.41	0.001	100
A-V-35	2.28	0.001	100
B-V-20	1.49	0.002	100
B-V-35	1.50	0.002	100
C-V-20	2.29	0.002	50
C-V-35	2.85	0.002	70
D-V-20	0.14	0.001	0
D-V-35	0.05	0.001	0
E-V-20	0.05	0.000	0
E-V-35	0.07	0.000	0
F-V-20	0.05	0.000	0
F-V-35	0.06	0.000	0
G-V-20	0.06	0.000	0
G-V-35	0.07	0.000	0
H-V-20	0.01	0.000	0
H-V-35	0.01	0.000	0

20 minutes - top coat removed on first and second coupons, partially on third. Some primer removed on first and second.

35 minutes - same as above

STRIPPER: QUICK STRIP #8 **DATE:** 10-10-85

Coupon Code #	% Weight Loss	Thickness Loss In Inches	% Top Coat Removal
A-VI-20	2.57	0.002	100
A-VI-35	2.64	0.002	100
B-VI-20	2.31	0.001	100
B-VI-35	1.81	0.001	100
C-VI-20	4.21	0.002	99
C-VI-35	4.69	0.002	99
D-VI-20	0.54	0.000	3
D-VI-35	9.78	0.005	100
E-VI-20	4.35	0.002	100
E-VI-35	4.10	0.002	100
F-VI-20	3.97	0.002	100
F-VI-35	4.22	0.002	100
G-VI-20	4.55	0.002	100
G-VI-35	4.51	0.002	100
H-VI-20	0.63	0.001	100
H-VI-35	0.66	0.001	100

20 minutes - top coat removed on all coupons except D-VI. Primer partially removed on first 3 coupons, not removed on 4, and removed on other coupons.

35 minutes - top coat removed on all coupons. Primer removed on all except A-VI-35, B-VI-35, and C-VI-35

STRIPPER: MS-111 #1 DATE: 10-3-85

Coupon Code #	% Weight Loss	Thickness Loss In Inches	% Top Coat Removal
A-VII-20	2.88	0.001	100
A-VII-35	2.92	0.001	100
B-VII-20	2.99	0.002	100
B-VII-35	2.63	0.002	100
C-VII-20	4.93	0.002	100
C-VII-35	4.80	0.002	100
D-VII-20	10.20	0.006	100
D-VII-35	10.16	0.006	100
E-VII-20	4.033	0.003	100
E-VII-35	4.023	0.003	100
F-VII-20	4.37	0.003	100
F-VII-35	4.45	0.003	100
G-VII-20	4.54	0.002	100
G-VII-35	4.53	0.002	100
H-VII-20	0.66	0.001	100
H-VII-35	0.65	0.001	100

20 minutes - top coat and primer removed on all coupons

35 minutes - same as above

STRIPPER: MS-111 #2 DATE: 10-9-85

Coupon Code #	% Weight Loss	Thickness Loss In Inches	% Top Coat Removal
A-VII-20	3.36	0.002	100
A-VII-35	3.08	0.002	100
B-VII-20	2.80	0.001	100
B-VII-35	2.51	0.001	100
C-VII-20	4.65	0.002	100
C-VII-35	4.61	0.002	100
D-VII-20	10.13	0.005	100
D-VII-35	9.75	0.005	100
E-VII-20	4.21	0.002	100
E-VII-35	4.13	0.002	100
F-VII-20	4.51	0.002	100
F-VII-35	4.52	0.002	100
G-VII-20	4.19	0.002	100
G-VII-35	4.48	0.002	100
H-VII-20	0.77	0.001	100
H-VII-35	0.19	0.001	100

20 minutes - top coat and primer removed from all coupons.

35 minutes - same as above

STRIPPER: OAKITE ALM DATE: 10-10-85

Coupon Code #	% Weight Loss	Thickness Loss In Inches	% Top Coat Removal
A-VIII-20	2.14	0.001	100
A-VIII-35	2.56	0.002	100
B-VIII-20	2.27	0.001	100
B-VIII-35	2.58	0.001	100
C-VIII-20	1.26	0.001	25
C-VIII-35	1.17	0.001	25
D-VIII-20	0.096	0.000	0
D-VIII-35	0.074	0.000	0
E-VIII-20	0.067	0.000	0
E-VIII-35	0.048	0.000	0
F-VIII-20	0.051	0.000	0
F-VIII-35	0.061	0.000	0
G-VIII-20	0.064	0.000	0
G-VIII-35	0.061	0.000	0
H-VIII-20	0.022	0.000	0
H-VIII-35	0.013	0.000	0

20 minutes - top coat removed on first and second coupons, partially on third. Primer partially removed on first.

35 minutes - same as above.

STRIPPER: OAKITE FHS DATE: 10-14-85

Coupon Code #	% Weight Loss	Thickness Loss In Inches	% Top Coat Removal
A-IX-20	3.96	0.001	100
A-IX-35	4.26	0.001	100
B-IX-20	3.74	0.001	100
B-IX-35	4.21	0.001	100
C-IX-20	5.13	0.001	100
C-IX-35	4.95	0.001	100
D-IX-20	0.32	0.000	0
D-IX-35	1.25	0.000	0
E-IX-20	2.90	0.002	50
E-IX-35	0.19	+0.001 * *	50
F-IX-20	4.50	0.001	95
F-IX-35	2.45	0.001	50
G-IX-20	0.65	+0.002 * *	20
G-IX-35	2.96	0.001	10
H-IX-20	-0.05 *	+0.001 * *	0
H-IX-35	0.70	0.001	100

20 minutes - top coat removed on first, second and third coupons, partially on fifth, sixth, and seventh. Primer removed on first, second, and third.

35 minutes - same as above

* Weight gain observed for coupons with zero (0) to minimal removal of top coat attributed to stripper and/or caustic trapped during stripping process.

** Gain in thickness is attributed to uniform bubbling of top coat during stripping process.

STRIPPER: OAKITE ALM
@ 180°F

DATE: 10-16-85

Coupon Code #	% Weight Loss	Thickness Loss In Inches	% Top Coat Removal
A-X-20	3.14	0.002	100
A-X-35	3.17	0.002	100
B-X-20	2.26	0.001	100
B-X-35	2.25	0.001	100
C-X-20	4.82	0.002	100
C-X-35	4.80	0.002	100
D-X-20	-0.32 *	0.000	0
D-X-35	-0.37 *	0.000	0
E-X-20	3.75	0.002	100
E-X-35	3.83	0.002	100
F-X-20	4.53	0.002	100
F-X-35	3.86	0.002	100
G-X-20	3.75	0.002	100
G-X-35	3.79	0.002	100
H-X-20	0.62	0.001	100
H-X-35	0.67	0.001	100

20 minutes - top coat and primer removed on all coupons except D.

35 minutes - same as above.

* Weight gain observed for coupons with zero (0) to minimal removal of top coat attributed to stripper and/or caustic trapped during stripping process.

STRIPPER: S-26, 1:1 dilution **DATE:** 10-17-85

AGED COUPONS

Coupon Code #	% Weight Loss	Thickness Loss In Inches	% Top Coat Removal
5-III	4.64	0.020	100
9-III	2.88	0.020	100
13-III	6.04	0.019	100
17-III	5.47	0.020	100

Top Coat and primer removed from all coupons.

Dipping time in stripper - 35 minutes.

STRIPPER: MS-111 DATE: 10-17-85

AGED COUPONS

Coupon Code #	% Weight Loss	Thickness Loss In Inches	% Top Coat Removal
4-VII	2.81	0.019	100
8-VII	3.29	0.017	100
12-VII	4.28	0.018	100
16-VII	4.36	0.017	100

Top coat and primer removed from all coupons

Dipping time in stripper - 35 minutes.

STRIPPER: S-26, 1:1 dilution **DATE:** 10-17-85

AGED COUPONS

Coupon Code #	% Weight Loss	Thickness Loss In Inches	% Top Coat Removal
5-III	4.64	0.020	100
9-III	2.88	0.020	100
13-III	6.04	0.019	100
17-III	5.47	0.020	100

Top Coat and primer removed from all coupons.

Dipping time in stripper - 35 minutes.

STRIPPER: QUICK STRIP #8 **DATE:** 10-17-85

AGED COUPONS

Coupon Code #	% Weight Loss	Thickness Loss In Inches	% Top Coat Removal
6-VI	2.20	0.021	100
10-VI	5.46	0.019	100
14-VI	4.26	0.020	100
18-VI	5.95	0.020	100

Top coat and primer removed from all coupons.

Dipping time in stripper - 35 minutes.

TABLE V PERCENT (%) WEIGHT LOSS 3 COUPONS FROM 11½" x 11½" PANELS

Average of duplicate runs

	A		B		C		D		E		F		G		H	
	20	35	20	35	20	35	20	35	20	35	20	35	20	35	20	35
VII	3.1	3.0	2.9	2.6	4.8	4.7	10.2	10.0	4.1	4.1	4.4	4.5	4.4	4.5	0.7	0.7
III	3.1	3.6	2.4	2.4	4.8	4.9	9.9	9.9	4.1	4.0	4.0	4.5	4.1	3.9	0.7	0.7
XI	3.3	3.3	2.7	2.7	5.0	5.0	10.8	11.0	3.9	4.6	4.1	3.5	3.8	4.3	0.7	0.8
VI	2.6	2.6	2.3	1.8	4.2	4.7	0.5	9.8	4.4	4.1	4.0	4.2	4.6	4.5	0.6	0.7
IX	4.0	4.3	3.7	4.2	5.1	5.0	0.3	1.3	2.9	0.2	4.5	2.5	0.7	3.0	-0.1	0.7
X	3.1	3.2	2.3	2.3	4.8	4.8	-0.3	-0.4	3.8	3.8	4.5	3.9	3.8	3.8	0.6	0.7
II	2.7	3.0	1.4	1.4	2.6	3.9	-0.8	4.6	-0.2	-0.3	-0.3	-0.2	-0.3	-0.2	-0.1	-0.1
VIII	2.1	2.6	2.3	2.6	1.3	1.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	<0.1	<0.1
I	2.5	2.7	1.2	1.8	2.9	4.0	-0.4	-0.6	-0.2	-0.2	-0.2	-0.2	-0.3	-0.2	-0.4	-0.3
IV	2.9	2.9	1.4	1.5	3.4	3.8	-0.1	-0.1	0.1	<0.1	<0.1	0.1	<0.1	<0.1	≤0.1	≤0.1
V	2.4	2.3	1.5	1.5	2.3	2.9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	<0.1	<0.1

TABLE VI AVERAGE PERCENT (%) WEIGHT LOSS FOR COUPONS FROM 11½" x 11½" PANELS

CODE	STRIPPER	% AVERAGE FOR 20 MIN.	% AVERAGE FOR 35 MIN.	% AVERAGE FOR TOTAL
VII	MS-111 *	4.3	4.3	4.3
XI	S-26 diluted 1:1	4.2	4.4	4.3
III	S-26	4.1	4.2	4.15
VI	Quick Strip #8	2.9	4.1	3.5
X	ALM 180°F	2.9	2.8	2.85
IX	FHS	2.7	2.6	2.65
II	M-Pyrol 140641	0.8	1.6	1.2
IV	Stripeeze	1.0	1.0	1.0
I	Nalco 84TB-227	0.8	1.1	0.95
V	Kutzit	0.8	0.9	0.85
VIII	ALM	0.7	0.8	0.75

* Average of duplicate runs

TABLE VII PERCENT (%) WEIGHT LOSS FOR AGED COATINGS

	Coupons			Coupons			Coupons			Coupons			Ave
	4	5	6	8	9	10	12	13	14	16	17	18	
VII	2.8			3.3			4.3			4.7			3.8
XI		4.6			2.9			6.0			5.5		4.8
VI			2.2			5.5			4.3			6.0	4.5

Erratic results for coupons within each group was attributed to a combination of top coat and primer on the back side of each coupon.

TABLE VIII VOLUME LOSS DURING STRIPPING PROCESS

CODE	STRIPPER	INITIAL VOLUME	FINAL VOLUME	% LOSS
I	Nalco #4TB-227	3500 ml	3500 ml	0
II	GAF M-Pyrol	3500 ml	3500 ml	0
III	Enthone S-26	3500 ml	3400 ml	2.9
IV	Stripeeze	3500 ml	3400 ml	2.9
V	Kutzit	3500 ml	3500 ml	0
VI	Quick Strip #8	3500 ml	3400 ml	2.9
VII	MS-111	3500 ml	3400 ml	2.9
VIII	Oakite ALM @ R. T.	3500 ml	3500 ml	0
IX	Oakite FHS	3500 ml	3500 ml	0
X	Oakite ALM @ 180°F	3500 ml	3200 ml	8.6
XI	S-26, 1:1 dilution	3500 ml	3400 ml	2.9

6.0 CONCLUSIONS

6.1 Based on the test evaluation, weight loss, and visual observations, the stripping formulations were ranked as indicated below.

RANKING OF STRIPPING FORMULATIONS FOR
COUPONS FROM 11¼" x 11¼" PANELS

RANK	CODE	STRIPPING FORMULATION
1	VII	MS-111
2	XI	S-26, 1:1 dilution
3	III	S-26
4	VI	Quick Strip #8
5	X	ALM @ 180°F (Oakite)
6	IX	FHS (Oakite)
7	II	M-Pyrol 14641
8	I	Nalco 84TB-227
9	IV	Stripeeze
10	V	Kutzit
11	VIII	ALM (Oakite)

The stripping abilities of MS-111 and S-26, diluted 1:1, were almost identical. However, MS-111 was just as effective at 20 minutes as it was at 35 minutes whereas, the S-26 was more effective with the longer dipping time. Quick Strip #8 was very effective on all coatings at 35 minutes dipping time but had very little effect on the epoxy coating (panel D) at 20 minutes. ALM at 180°F was very effective on all coatings except the epoxy (panel D) even at 35 minutes. The remaining strippers were very ineffective on epoxy and polyamide coatings (panels D-H). Most strippers, except for ALM (room temperature), were fairly effective on the enamel coatings.

6.2 MS-111, S-26 (1:1 dilution) and Quick Strip #8 were selected for evaluation on the aged coupons. Each stripper removed 100 percent of the top coat. Primer was also removed. Most of the top coat was removed with MS-111 and S-26 prior to steam cleaning. Remaining top coat on panels stripped with Quick Strip #8 was removed during steam cleaning.

RANKINGS OF STRIPPING FORMULATIONS FOR AGED COUPONS

RANK	CODE	STRIPPING FORMULATION
1	VII	MS-111
2	XI	S-26, 1:1 Dilution
3	VI	Quick Strip #8

7.0 RECOMMENDATIONS

7.1 Since Oakite ALM at elevated temperature gave satisfactory results on all coupons except the epoxy coated, additional evaluation may be warranted particularly since it does not contain phenols or methylene chloride.

7.2 Oakite FHS showed some top coat removal on all coupons except the epoxy coated. Therefore, it may warrant additional evaluation and is also free of phenols and methylene chloride.

7.3 Any future testing should include coupon submittals with only the primer coating and bare metal coupons so that a more thorough evaluation of primer removal can be made.

APPENDIX C

MATERIAL SAFETY DATA SHEETS

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

Form Approved
OMB No. 44-R1387

MATERIAL SAFETY DATA SHEET

SECTION I

MANUFACTURER'S NAME ENTHONE, INC.	EMERGENCY TELEPHONE NO. 203 - 934-8611
ADDRESS (Number, Street, City, State, and ZIP Code) P. O. Box 1900, New Haven, CT 06508	
CHEMICAL NAME AND SYNONYMS Paint Stripper	TRADE NAME AND SYNONYMS STRIPPER S-26
CHEMICAL FAMILY N/A	FORMULA N/A

SECTION II - HAZARDOUS INGREDIENTS

PAINTS, PRESERVATIVES, & SOLVENTS	%	TLV (Units)	ALLOYS AND METALLIC COATINGS	%	TLV (Units)
PIGMENTS			BASE METAL		
CATALYST			ALLOYS		
VEHICLE			METALLIC COATINGS		
SOLVENTS			FILLER METAL PLUS COATING OR CORE FLUX		
ADDITIVES			OTHERS*		
OTHERS					

HAZARDOUS MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES	%	TLV (Units)
(This is methylene chloride) → Chlorinated Hydrocarbon <	60	250ppm
Aliphatic Acid <	15	5ppm
Phenol <	30	5ppm

SECTION III - PHYSICAL DATA

BOILING POINT (°F.)	139°F.	SPECIFIC GRAVITY (H_2O=1)	1.18
VAPOR PRESSURE (mm Hg.) approx.	400mm Hg	PERCENT, VOLATILE BY VOLUME (%) @ 110°F. @ 215°F.	55% 90%
VAPOR DENSITY (AIR=1)	–	EVAPORATION RATE (________ =1)	
SOLUBILITY IN WATER	soluble		
APPEARANCE AND ODOR	Dark brown liquid with strong, sharp, phenolic odor.		

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

		Lel	Uel
FLASH POINT (Method used) None	FLAMMABLE LIMITS autoignition point of 1100°F.		
EXTINGUISHING MEDIA in a fire - Foam, CO_2			
SPECIAL FIRE FIGHTING PROCEDURES —			
UNUSUAL FIRE AND EXPLOSION HAZARDS Has no flash or fire point; but after major constituent has been completely evaporated, residue has flash point of 156°F. (open cup)			

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(Continued on reverse side)

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SECTION V - HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE N/A

EFFECTS OF OVEREXPOSURE
Rapidly damaging to eyes, nose, throat, skin, mucous membranes. Possible damage to kidney, respiratory and nervous system. Possible systemic effect via skin absorption.

EMERGENCY AND FIRST AID PROCEDURES
EXTERNAL : Remove contaminated clothing immediately. Flush with cool water for 15 minutes. Wash affected areas with soap and water. Get immediate medical attention.
INTERNAL : Swallow milk of magnesia or olive oil. Report to doctor immediately.
EYES: Flush with cool water for 15 minutes and get immediate medical attention.
INHALATION : Remove to fresh air. Apply artificial respiration and oxygen if necessary. Get immediate medical attention

SECTION VI - REACTIVITY DATA

STABILITY	UNSTABLE		CONDITIONS TO AVOID
	STABLE	X	

INCOMPATABILITY *(Materials to avoid)* Oxidizers, alkalis

HAZARDOUS DECOMPOSITION PRODUCTS In a fire - Phosgene, HCl, CO, CO_2, misc. oxygenated hydrocarbons

HAZARDOUS POLYMERIZATION	MAY OCCUR		CONDITIONS TO AVOID
	WILL NOT OCCUR	X	

SECTION VII - SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED
Avoid contact with skin, eyes and clothing. Use rubber gloves, protective clothing and face shield. Avoid breathing fumes. If spilled in a confined area, use self-contained breathing apparatus.

WASTE DISPOSAL METHOD for spills and leaks:
SMALL SPILLS : Mop up, wipe up or soak up and remove outdoors.
LARGE SPILLS : Isolate area. Contain liquid with sand or gravel. Pump liquid to closed polyethylene-lined containers or soak up in suitable absorbent. Transfer material to chemical waste treatment facility. Keep out of water supply. If spill reaches water supply, stream, or sewer, notify proper authorities
For waste Disposal of Operating Solutions, Consult Enthone Operating Instructions.

SECTION VIII - SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION *(Specify type)* Type for organic vapors.

VENTILATION	LOCAL EXHAUST Yes, if general area ventilation is not good	SPECIAL	—
	MECHANICAL *(General)* —	OTHER	—

PROTECTIVE GLOVES Yes, rubber

EYE PROTECTION Yes, face shield

OTHER PROTECTIVE EQUIPMENT Protective clothing or apron, boots

SECTION IX - SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING
Keep closed to prevent evaporation. Store at max. of 100°F. Avoid skin contact.

OTHER PRECAUTIONS Exothermic reaction with strong oxidizing agents.

10/79

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

Form Approved
OMB No. 44-R1387

MATERIAL SAFETY DATA SHEET

Required under USDL Safety and Health Regulations for Ship Repairing, Shipbuilding, and Shipbreaking (29 CFR 1915, 1916, 1917)

SECTION I

MANUFACTURER'S NAME Miller-Stephenson Chemical Company, Inc.	EMERGENCY TELEPHONE NO. (203) 743-4447
ADDRESS (Number, Street, City, State, and ZIP Code) George Washington Highway, Danbury, Connecticut 06810	
CHEMICAL NAME AND SYNONYMS Not applicable Mixture	TRADE NAME AND SYNONYMS MS-111 Stripping Agent
CHEMICAL FAMILY Not applicable	FORMULA Not applicable

SECTION II - HAZARDOUS INGREDIENTS

PAINTS, PRESERVATIVES, & SOLVENTS	%	TLV (Units)	ALLOYS AND METALLIC COATINGS	%	TLV (Units)
PIGMENTS			BASE METAL		
CATALYST			ALLOYS		
VEHICLE			METALLIC COATINGS		
SOLVENTS Methylene Chloride CAS# 75-09-2	70-90%	500*ppm	FILLER METAL PLUS COATING OR CORE FLUX		
ADDITIVES			OTHERS		
[illegible] Formic Acid CAS# 64-18-6	6-10%	5 ppm			

HAZARDOUS MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES	%	TLV (Units)
Phenol CAS# 108-95-2	5-10%	5 ppm

* Based on OSHA's value of 500 ppm for Methylene Chloride. However, the American Conference of Governmental Industrial Hygienists (ACGIH) has published a value of 100 ppm for Methylene Chloride which would yield a TLV of~22 ppm for MS-111. See Section V - TLV.

SECTION III - PHYSICAL DATA

BOILING POINT (°F.)	initial	104	SPECIFIC GRAVITY (H_2O=1) 77°F	1.25
VAPOR PRESSURE (mm Hg.)	68°F	340	PERCENT, VOLATILE BY VOLUME (%)	90
VAPOR DENSITY (AIR=1)	68°F	2.93	EVAPORATION RATE (ether =1) initial	0.6
SOLUBILITY IN WATER		moderate	pH =	1.5
APPEARANCE AND ODOR	Volatile liquid with sharp acid odor			

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (Method used) Nonflammable til 80% evaporated	FLAMMABLE LIMITS	Lel	Uel

EXTINGUISHING MEDIA
Carbon dioxide or foam

SPECIAL FIRE FIGHTING PROCEDURES

UNUSUAL FIRE AND EXPLOSION HAZARDS
In open flames or high temperatures HCl and slight amounts of phosgene may be generated.

(Continued on reverse side)

SECTION V - HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE Evaporated residue: Skin sensitivity 5 ppm (estimated)
Volatile vapors ~26 ppm* as calculated by the ACGIH method for TLV of mixtures.

EFFECTS OF OVEREXPOSURE
Vapors are irritating, and may cause slight nausea, and dizziness. Skin contact will cause immediate burning sensation. Eye contact will cause extreme and prolonged irritation.

EMERGENCY AND FIRST AID PROCEDURES
Skin contact: Flush with copious amounts of water and apply a wet dressing of 5% solution of sodium thiosulfate. Treat as with acid burns and follow medical advise.
Eye contact: Flush eyes for 10 - 15 minutes with copious amounts of water and immediately consult a physician.

SECTION VI - REACTIVITY DATA

STABILITY	UNSTABLE		CONDITIONS TO AVOID
	STABLE	XX	

INCOMPATABILITY *(Materials to avoid)*

HAZARDOUS DECOMPOSITION PRODUCTS
In flames generates hydrochloric acid and some phosgene.

HAZARDOUS POLYMERIZATION	MAY OCCUR		CONDITIONS TO AVOID
	WILL NOT OCCUR	XX	

SECTION VII – SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED
Ventilate area, remove flames and red hot surfaces. Allow to evaporate.
Neutralize residue with 5% soda solution and remove to containers for disposal.
Flush area with large amounts of water.

WASTE DISPOSAL METHOD
In containers to landfill, local regulations permitting. Consult local waste disposal contractor.

SECTION VIII - SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION *(Specify type)* under conditions of low ventilation
Independent air supply-carbon canister - organic vapor respirator.

VENTILATION highly recommended	LOCAL EXHAUST Forced air	SPECIAL Vapor may concentrate in low areas.
	MECHANICAL *(General)*	OTHER

PROTECTIVE GLOVES Viton, acid resistant	EYE PROTECTION Face shield, goggles

OTHER PROTECTIVE EQUIPMENT Eye fountain, Shower station, Protective aprons

SECTION IX - SPECIAL PRECAUTIONS

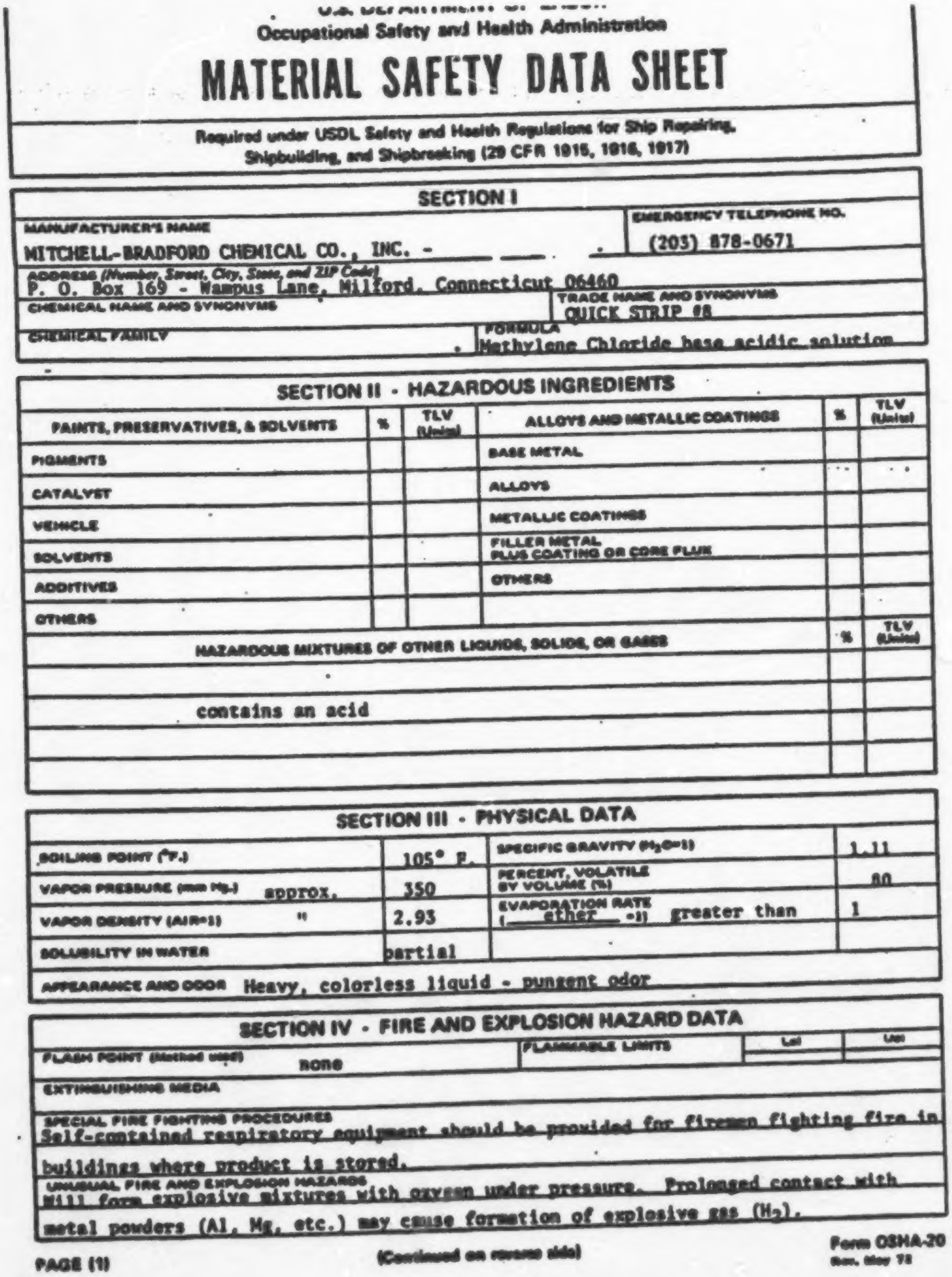
PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING
Store out of sunlight in a cool room. Avoid contact with skin and clothes.
Wear rubber apron or protective clothing.

OTHER PRECAUTIONS
Open containers carefully and only when cooled to room temperature. Do not mix with other solvents.

PAGE (2)
REVISED April 10, 1985
BY Deborah Chucta
Chief Chemist

Deborah Chucta

Form OSHA-20
Rev. May 72



U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

MATERIAL SAFETY DATA SHEET

Required under USDL Safety and Health Regulations for Ship Repairing,
Shipbuilding, and Shipbreaking (29 CFR 1915, 1916, 1917)

SECTION I

MANUFACTURER'S NAME: MITCHELL-BRADFORD CHEMICAL CO., INC.
EMERGENCY TELEPHONE NO.: (203) 878-0671
ADDRESS (Number, Street, City, State, and ZIP Code): P. O. Box 169 - Wampus Lane, Milford, Connecticut 06460
CHEMICAL NAME AND SYNONYMS:
TRADE NAME AND SYNONYMS: QUICK STRIP #8
CHEMICAL FAMILY:
FORMULA: Methylene Chloride base acidic solution

SECTION II - HAZARDOUS INGREDIENTS

PAINTS, PRESERVATIVES, & SOLVENTS	%	TLV (Units)	ALLOYS AND METALLIC COATINGS	%	TLV (Units)
PIGMENTS			BASE METAL		
CATALYST			ALLOYS		
VEHICLE			METALLIC COATINGS		
SOLVENTS			FILLER METAL PLUS COATING OR CORE FLUX		
ADDITIVES			OTHERS		
OTHERS					

HAZARDOUS MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES	%	TLV (Units)
contains an acid		

SECTION III - PHYSICAL DATA

BOILING POINT (°F.)	105° F.	SPECIFIC GRAVITY ($H_2O=1$)	1.11
VAPOR PRESSURE (mm Hg.) approx.	350	PERCENT, VOLATILE BY VOLUME (%)	80
VAPOR DENSITY (AIR=1) "	2.93	EVAPORATION RATE (ether =1) greater than	1
SOLUBILITY IN WATER	partial		

APPEARANCE AND ODOR: Heavy, colorless liquid - pungent odor

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (Method used) none	FLAMMABLE LIMITS	Lel	Uel

EXTINGUISHING MEDIA:

SPECIAL FIRE FIGHTING PROCEDURES: Self-contained respiratory equipment should be provided for firemen fighting fire in buildings where product is stored.

UNUSUAL FIRE AND EXPLOSION HAZARDS: Will form explosive mixtures with oxygen under pressure. Prolonged contact with metal powders (Al, Mg, etc.) may cause formation of explosive gas (H_2).

PAGE (1)

(Continued on reverse side)

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This data pertains to undiluted
product, not dilutions of product.

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U.S. DEPARTMENT OF LABOR
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MATERIAL SAFETY DATA SHEET

Required under USDL Safety and Health Regulations for Ship Repairing, Shipbuilding, and Shipbreaking (29 CFR 1915, 1916, 1917)

SECTION I

MANUFACTURER'S NAME OAKITE PRODUCTS, INC.	EMERGENCY TELEPHONE NO. (201) 464-6900
ADDRESS (Number, Street, City, State, and ZIP Code) 50 Valley Road, Berkeley Heights, New Jersey 07922	
CHEMICAL NAME AND SYNONYMS	TRADE NAME AND SYNONYMS Oakite Stripper ALM
CHEMICAL FAMILY Alkali solvent	FORMULA Proprietary mixture

SECTION II - HAZARDOUS INGREDIENTS

PAINTS, PRESERVATIVES, & SOLVENTS	%	TLV (Units)	ALLOYS AND METALLIC COATINGS	%	TLV (Units)
PIGMENTS			BASE METAL		
CATALYST			ALLOYS		
VEHICLE			METALLIC COATINGS		
SOLVENTS *			FILLER METAL PLUS COATING OR CORE FLUX		
ADDITIVES			OTHERS		
OTHERS					

HAZARDOUS MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES	%	TLV (Units)
Tributyl phosphate	<5	0.2PPM
* Furfuryl alcohol	< 10	10PPM (skin
Monoethanolamine	10	3 PPM
Sodium hydroxide	<1	2mg/M^3

NONE OF THE REMAINING INGREDIENTS HAVE TLV'S ESTABLISHED BY ACGIH OR OSHA.

SECTION III - PHYSICAL DATA

BOILING POINT (°F.)	Unknown	SPECIFIC GRAVITY (H_2O=1)	1.045
VAPOR PRESSURE (mm Hg.)	Unknown	PERCENT, VOLATILE BY VOLUME (%)	
VAPOR DENSITY (AIR=1)	Unknown	EVAPORATION RATE (________ =1)	
SOLUBILITY IN WATER	Complete	pH at full strength	13+
APPEARANCE AND ODOR	Brown liquid; alcohol-type odor.		

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (Method used) None to 185°F. Tag OpenCup	FLAMMABLE LIMITS	N/A	Lel	Uel

EXTINGUISHING MEDIA
Carbon dioxide, alcohol foam, dry chemical.

SPECIAL FIRE FIGHTING PROCEDURES
Firemen should wear standard protective clothing including proper respiratory protection. Nitrogen oxides can be evolved.

UNUSUAL FIRE AND EXPLOSION HAZARDS
None known. If water evaporates off, remaining solvents may have a flash point or be burnable.

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(Continued on reverse side)
N/A = Not applicable
11/28/83
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[redacted]

[redacted]

Oakite Stripper ALM

SECTION V - HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE Mixture: unknown. See Section II.

EFFECTS OF OVEREXPOSURE
Direct contact with eyes causes irritation possible burns. Prolonged skin contact causes irritation. Prolonged inhalation of high vapor concentrations may cause upper respiratory tract irritation.

EMERGENCY AND FIRST AID PROCEDURES
Immediately flush eyes with plenty of water for at least 15 minutes; get medical attention. Wash skin thoroughly with water or soap and water. Remove contaminated clothing and shoes and wash before reuse. For inhalation, remove from exposure. In case of overexposure, contact a physician.

SECTION VI - REACTIVITY DATA

STABILITY	UNSTABLE		CONDITIONS TO AVOID
	STABLE	X	

INCOMPATABILITY *(Materials to avoid)* Acids and oxidizing agents, nitrites or nitrates.

HAZARDOUS DECOMPOSITION PRODUCTS
Burning can produce carbon monoxide, carbon dioxide and nitrogen oxide.

HAZARDOUS POLYMERIZATION	MAY OCCUR		CONDITIONS TO AVOID
	WILL NOT OCCUR		

SECTION VII - SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED Add absorbent--Collect for disposal.

WASTE DISPOSAL METHOD Observe all federal, state and local regulations.
Haul away concentrate.

SECTION VIII - SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION *(Specify type)* In absence of proper environmental control, air supplied mask may be needed in confined areas.

VENTILATION	LOCAL EXHAUST Provide adequate ventilation for removal of vapors.	SPECIAL
	MECHANICAL *(General)*	OTHER

PROTECTIVE GLOVES Impervious gloves	EYE PROTECTION Safety goggles

OTHER PROTECTIVE EQUIPMENT
Apron and/or other protective clothing; face shield. Recommend eye wash and safety shower near work area.

SECTION IX - SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING
Avoid contact with eyes, skin and clothing. Avoid breathing vapor. Use only with adequate ventilation. Wash thoroughly after handling. Suitable for

OTHER PRECAUTIONS
general indoor storage at moderate temperatures. Keep away from acids, oxidizing agents, heat or open flame. KEEP FROM FREEZING. Restores on thawing. Keep container closed when not in use.

The information herein is given
in good faith, but no warranty,
expressed or implied is made.

This data pertains to undiluted
product, not dilutions of product.

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U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

Form Approved
OMB No. 44-R1387

MATERIAL SAFETY DATA SHEET

Required under USDL Safety and Health Regulations for Ship Repairing, Shipbuilding, and Shipbreaking (29 CFR 1915, 1916, 1917)

SECTION I

MANUFACTURER'S NAME OAKITE PRODUCTS, INC.	EMERGENCY TELEPHONE NO. (201) 464-6900
ADDRESS *(Number, Street, City, State, and ZIP Code)* 50 Valley Road, Berkeley Heights, New Jersey 07922	
CHEMICAL NAME AND SYNONYMS	TRADE NAME AND SYNONYMS Oakite Stripper FHS
CHEMICAL FAMILY Solvent-acid	FORMULA Proprietary

SECTION II - HAZARDOUS INGREDIENTS

PAINTS, PRESERVATIVES, & SOLVENTS	%	TLV (Units)	ALLOYS AND METALLIC COATINGS	%	TLV (Units)
PIGMENTS			BASE METAL		
CATALYST			ALLOYS		
VEHICLE			METALLIC COATINGS		
SOLVENTS Mixed aromatic hydrocarbons	10	200PPM	FILLER METAL PLUS COATING OR CORE FLUX		
ADDITIVES			OTHERS		
OTHERS					

HAZARDOUS MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES	%	TLV (Units)
Butyl callosolve CAS No. 111-76-2	35	25PPM
Formic acid CAS No. 64-18-6	15	5PPM
Hydrofluoric acid CAS No. 7664-39-3	<5	3PPM as F
Diisobutyl ketone CAS No. 108083-8	10	25PPM
Dodecylbenzene Sulfonic Acid CAS No. 27176-87-0		

SECTION III - PHYSICAL DATA

BOILING POINT (°F.)	Unknown	SPECIFIC GRAVITY (H_2O=1)	0.978
VAPOR PRESSURE (mm Hg.)	Unknown	PERCENT, VOLATILE BY VOLUME (%)	50%
VAPOR DENSITY (AIR=1)	Unknown	EVAPORATION RATE (________ =1)	Unknown
SOLUBILITY IN WATER	N/A	pH at full strength	1.0
APPEARANCE AND ODOR Clear amber liquid; acidic odor.			

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (Method used) 150°F., Tag Closed Cup	FLAMMABLE LIMITS Unknown	Lel	Uel

EXTINGUISHING MEDIA
Alcohol foam, dry chemical, carbon dioxide.

SPECIAL FIRE FIGHTING PROCEDURES
Firemen should wear full protective clothing including respiratory protection.

UNUSUAL FIRE AND EXPLOSION HAZARDS Keep away from oxidizing materials.

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N/A = Not Applicable

Oakite Stripper FHS

SECTION V - HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE Mixture: unknown. See Section II.

EFFECTS OF OVEREXPOSURE
Contact with eyes and skin causes severe burns. Inhalation of concentrated vapors or mists causes irritation of mucous membranes and may cause headache, nausea, dizziness.

EMERGENCY AND FIRST AID PROCEDURES See attached sheet.

SECTION VI - REACTIVITY DATA

STABILITY	**UNSTABLE**		**CONDITIONS TO AVOID** Direct sunlight, heat and open flames.
	STABLE	X	

INCOMPATABILITY *(Materials to avoid)*
Strong oxidizing materials; chlorine-releasing materials; alkaline materials.

HAZARDOUS DECOMPOSITION PRODUCTS
Thermal decomposition may yield acidic fumes, carbon monoxide and carbon dioxide.

HAZARDOUS POLYMERIZATION	**MAY OCCUR**		**CONDITIONS TO AVOID**
	WILL NOT OCCUR	X	

SECTION VII - SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED
Absorb with straw, sawdust, or other absorbing material and sweep up, then wash area with detergent and water. Provide adequate ventilation. Employees cleaning up major spills should wear protective clothing and use respiratory protection. Keep away from open flame and heat sources.

WASTE DISPOSAL METHOD Observe all federal, state and local regulations.
Concentrate should be hauled away.

SECTION VIII - SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION *(Specify type)*

VENTILATION	**LOCAL EXHAUST** Provide adequate ventilation to maintain levels	**SPECIAL**
	MECHANICAL *(General)* of vapors or mists below TLV.	**OTHER**

PROTECTIVE GLOVES Impervious gloves

EYE PROTECTION Safety goggles

OTHER PROTECTIVE EQUIPMENT
Apron and/or other suitable protective clothing; face shield.
Recommend eye wash and safety shower near use area.

SECTION IX - SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING
Avoid contact with eyes, skin and clothing. Wash thoroughly after handling. Avoid prolonged or repeated breathing of vapor. Store in a cool, dry place out of direct sunlight and away from heat and open flames.

OTHER PRECAUTIONS
Thickens at low temperatures. Freezes at 3°F (-16.1°C). Before opening, relieve any pressure build-up by loosening closure slowly. Keep container closed when not in us

METHYLENE CHLORIDE

Nonreactive
0
Slightly Combustible
1
High Health Hazard
3
Ratings based on NIOSH "Identification System for Occupationally Hazardous Materials" (1974)

Industrial Chemicals Group
Diamond Shamrock Corporation
351 Phelps Court
P.O. Box 2300
Irving, Texas 75061
214/888-7000

Diamond Shamrock

Material Safety Data Sheet

GENERAL INFORMATION Methylene Chloride is a clear, colorless non-flammable liquid with a sweet odor perceptible at concentrations below 250 ppm.

DEPARTMENT OF TRANSPORTATION INFORMATION
PROPER SHIPPING NAME: Methylene Chloride HAZARD CLASS: ORM-A
I.D. NUMBER: UN 1593

I PRODUCT IDENTIFICATION

Manufacturer's Name
DIAMOND SHAMROCK CORPORATION

Regular Telephone No. Contact Local Sales Office
Emergency Telephone No. 216/357-7070

Address
Industrial Chemicals Technical Center
P.O. Box 191
Painesville, Ohio 44077

Product Name
Methylene Chloride

Synonyms
Dichloromethane (CH_2Cl_2)

II HAZARDOUS INGREDIENTS

Material or component	CAS No.[+]	%	Hazard Data
Methylene Chloride	75-09-2	100	PEL* = 500 ppm (8-hr. TWA) 1000 PPM CEILING VALUE 2000 ppm peak (5 minutes in any 2 hrs.) TLV** = 100 ppm (8-hr. TWA) NIOSH recommended standard -- air: TWA 75 ppm; peak 500 ppm for 15 minutes.

[+] Chemical Abstract Service Number
*OSHA Permissible Exposure Limit
**ACGIH Threshold Limit Value, 1982

All information recommendations and suggestions appearing herein concerning our product are based upon tests and data believed to be reliable. However, it is the user's responsibility to determine the safety, toxicity, and suitability for his own use of the product described herein. Since the actual use by others is beyond our control, no guarantee, expressed or implied, is made by Diamond Shamrock Corporation as to the effects of such use, the results to be obtained, or the safety and toxicity of the product nor does Diamond Shamrock Corporation assume any liability arising out of use, by others, of the product referred to herein. Nor is the information herein to be construed as absolutely complete since additional information may be necessary or desirable when particular or exceptional conditions or circumstances exist or because of applicable laws or government regulations.

CA-MSDS-8782

III PHYSICAL DATA

Boiling Point, 760 mm Hg
39.8°C (104°F)

Specific Gravity (H_2O=1)
1.32

Vapor Density (Air=1)
2.93

% Volatiles by Vol.
100

Appearance and Odor
Clear, colorless liquid
with an ether-like odor

pH
Not Applicable

Melting Point
Not Applicable

Freezing Point
-96.7°C (-142°F)

Vapor Pressure
420 mm Hg @ 25°C

Solubility in H_2O, % by Wt.
1.3

Evaporation Rate (Butyl Acetate=1)
0.62

Density at 20°C:
Not Available

IV FIRE AND EXPLOSION DATA

DEVELOP EMERGENCY ACTION PLAN

Flash Point (Test Method)
None (TCC)

Autoignition Temperature
662°C (1224°F)

Flammable Limits in Air, % by Vol. @ 25°C (77°F)	Lower 14	Upper 25

Extinguishing Media
Use water spray, dry chemical, foam or carbon dioxide.

Special Fire Fighting Procedures
Use water spray to keep fire-exposed containers cool. Pressure-demand self-contained breathing apparatus should be provided for fire fighters in buildings or confined areas where Methylene Chloride is stored.

Unusual Fire and Explosion Hazard
Methylene Chloride is nonflammable and nonexplosive under normal conditions of use. At high temperatures, Methylene Chloride decomposes to give off hydrochloric acid as gas plus other toxic and irritating vapors such as phosgene. If storage containers are exposed to excessive heat, overpressurization of the containers can result.

V HEALTH HAZARD INFORMATION

Health Hazard Data

Methylene Chloride:	Acute Oral	LD_{50} = 2000-4000 mg/kg (Rat)
	Acute Dermal	LD_{LO} = 2700 mg/kg (Rabbit)
	Acute Inhalation	LC_{50} = 24445 ppm (Rat)

Routes of Exposure

Inhalation

Excessive inhalation may produce symptoms of central nervous system depression, ranging from lightheadedness, nausea and vomiting, to unconsciousness and death.

Skin Contact

Mildly irritating to skin. Skin contact may produce a burning sensation. Prolonged or repeated contact may cause skin to become reddened, rough, and dry due to the removal of natural oils and may result in dermatitis.

Skin Absorption

Methylene Chloride may be absorbed through the skin, although not expected to produce toxicity through this route.

Eye Contact

An irritant to the eyes, causing pain, lacrimation, and general inflammation.

Ingestion

May cause irritation of the gastrointestinal tract with vomiting. If vomiting results in aspiration, chemical pneumonia could follow. Absorption through the gastrointestinal tract may produce symptoms of central nervous system depression ranging from light-headedness to unconsciousness.

Effects of Overexposure

Acute Overexposure

Excessive inhalation or ingestion may produce symptoms of central nervous system depression ranging from light-headedness, to unconsciousness and death. Exposure of the eyes and skin may produce irritation.

Chronic Overexposure

Can cause headache, mental confusion, depression, fatigue, loss of appetite, nausea, vomiting, cough, loss of sense of balance, and visual disturbances. Prolonged or repeated skin contact may cause dermatitis.

Emergency and First Aid Procedures

Eyes:

OBJECT IS TO FLUSH MATERIAL OUT THEN SEEK MEDICAL ATTENTION. IMMEDIATELY flush eyes with large amounts of water for at least 15 minutes holding lids apart to ensure flushing of the entire eye surface. Seek medical attention.

Skin:

Wash contaminated areas with plenty of soap and water. A soothing ointment may be applied to irritated skin after thorough cleansing. Remove contaminated clothing and footwear and wash clothing before reuse. Discard footwear which cannot be decontaminated. Seek medical attention.

Inhalation:

Get person out of contaminated area to fresh air. If breathing has stopped, resuscitate and administer oxygen if readily available. Seek medical attention immediately.

Ingestion:

NEVER give anything by mouth to an unconscious person. Have conscious patient drink several glasses of water then induce vomiting by having patient tickle back of throat with finger. Keep airway clear. Seek medical attention immediately.

Notes to Physician

Methylene Chloride overexposure can produce elevated carboxyhemoglobin levels.

VI REACTIVITY DATA

Conditions Contributing to Instability

Under normal conditions, the material is stable.

Incompatibility

Avoid contacting Methylene Chloride with pure oxygen, alkali metals, open flames, and electrical arcs.

Hazardous Decomposition Products

At high temperatures, Methylene Chloride decomposes to give off hydrogen chloride vapor and small quantities of other toxic irritating vapors such as phosgene.

Conditions Contributing to Hazardous Polymerization

Material is not known to polymerize.

VII SPILL OR LEAK PROCEDURES

DEVELOP SPILL PLAN

Steps to be Taken if Material is Released or Spilled

Leaks should be stopped. Spills should be contained and cleaned up immediately. Large spills should be removed by using a vacuum truck. Smaller spills may be soaked up with compatible absorbent materials which should then be placed in approved containers, labeled, and stored in a safe place out of doors to await proper disposal. The spill area should then be flushed with water. All rinsate should be removed and placed in approved containers to await proper treatment or disposal. Spills on areas other than pavement, e.g., dirt or sand, may be handled by removing the affected soils and placing in approved containers. Persons performing clean-up work should wear adequate personal protective equipment and clothing.

Waste Disposal Method

The materials resulting from clean-up operations may be hazardous wastes and therefore, subject to specific regulations. Package, store, transport and dispose of all clean-up materials and any contaminated equipment in accordance with all applicable Federal, State and local health and environmental regulations. Shipments of waste materials may be subject to manifesting requirements per applicable regulations. Appropriate disposal will depend on the nature of each waste material and should be performed by competent properly permitted contractors. Ensure that all responsible Federal, State and local agencies receive timely and proper notifications of the spill and disposal of waste.

VIII INDUSTRIAL HYGIENE CONTROL MEASURES

Ventilation Requirements

Work in well-ventilated areas. Where engineering controls are not feasible, use adequate local exhaust ventilation.

Specific Personal Protective Equipment

Respiratory (Specify in Detail)

Respiration protection is not required under normal use. However, if needed, use a NIOSH/MSHA approved respirator following manufacturer's recommendations.

Eye

Face shield and goggles or chemical splash goggles should be worn.

Gloves

Gloves should be worn. Consult the manufacturer for most appropriate glove material.

Other Clothing and Equipment

Standard work clothing. Chemically-resistant safety shoes. Wash contaminated clothing with soap and water and dry before reuse.

IX SPECIAL PRECAUTIONS

Precautionary Statements

DANGER!
VOLATILE SOLVENT.
PROLONGED BREATHING OF VAPOR CAN CAUSE LOSS OF CONSCIOUSNESS AND MAY RESULT IN DEATH.
CAUSES IRRITATION OF THE EYES, SKIN, AND RESPIRATORY TRACT.

DO NOT get in eyes, on skin, on clothing.
DO NOT take internally.
Avoid breathing vapors.
When handling, wear chemical splash goggles, protective clothing, and solvent-resistant gloves.
Wash thoroughly after handling.
Use with adequate ventilation in work area.
Employ respiratory protection when exposure to vapors is possible.
Avoid contact with flames, hot glowing surfaces, or alkali metals to prevent decomposition resulting in toxic and irritating vapors.
Keep container tightly closed.
Store in cool, ventilated place.

First Aid:

In case of contact:

For eyes: Immediately flush with plenty of water for at least 15 minutes, holding eyelids apart to ensure flushing of the entire eye surface. Seek medical attention immediately.

For skin: Wash with plenty of soap and water. A soothing ointment may be applied to irritated skin after cleansing. Remove contaminated clothing and footwear and wash clothing before reuse. Discard footwear which cannot be decontaminated. Seek medical attention.

If inhaled: Get person out of contaminated area to fresh air. If breathing has stopped, artificial respiration should be started. Oxygen may be administered, if available. Seek medical attention immediately.

If swallowed: If conscious, give several glasses of water to drink and induce vomiting by touching finger to back of throat. Keep airway clear. NEVER give anything by mouth to an unconscious person. Seek medical attention immediately.

Note to physician: Methylene Chloride overexposure can produce elevated carboxyhemoglobin levels.

In Case of Fire: Use CO_2, dry chemicals, foam or water fog.

In Case of Spill or Leak: Leaks should be stopped. Spills should be cleaned up immediately. Large spills should be contained and removed by vacuum truck. Smaller spills may be soaked up with absorbent materials, which should be placed in closed containers, labeled, and stored in a safe place out of doors to await proper disposal. Persons performing this work should wear adequate personal protective equipment and clothing.

For Industrial Use Only

Other Handling and Storage Requirements

STORAGE AND DISPOSAL

Storage

Under normal conditions, Methylene Chloride may be stored satisfactorily in galvanized iron, black iron or steel. Aluminum is not generally recommended for storage or handling. Store drums in a cool place (bungs up and closed tightly). Ventilation should be provided at the floor level. Do not store in pits, depressions, basements or unventilated areas. All tanks should have a top and bottom manhole and a vent of a diameter at least equal to that of the fill or discharge pipe. Vent indoor tanks outside in a location such that escaping vapor will not contaminate any work space air. Vertical tanks should be of the closed-top design. Normally, a dryer and safety seal on the vent is recommended.

Disposal

The materials resulting from clean-up operations may be hazardous wastes and therefore, subject to specific regulations. Package, store, transport, and dispose of all clean-up materials and any contaminated equipment in accordance with all applicable Federal, State, and local health and environmental regulations. Shipments of waste materials may be subject to manifesting requirements per applicable regulations. Appropriate disposal will depend on the nature of each waste material and should be performed by competent properly permitted contractors. Ensure that all responsible Federal, State, and local agencies receive proper notification of disposal.

All information, recommendations and suggestions appearing herein concerning our product are based upon tests and data believed to be reliable. However, it is the user's responsibility to determine the safety, toxicity, and suitability for his own use of the product described herein. Since the actual use by others is beyond our control, no guarantee, expressed or implied, is made by Diamond Shamrock Corporation as to the effects of such use, the results to be obtained, or the safety and toxicity of the product nor does Diamond Shamrock Corporation assume any liability arising out of use, by others, of the product referred to herein. The information herein is not to be construed as absolutely complete since additional information may be necessary or desirable when particular or exceptional conditions or circumstances exist or because of applicable laws or government regulations.

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NALCO CHEMICAL COMPANY
2901 BUTTERFIELD ROAD OAK BROOK, ILLINOIS 60521

MATERIAL SAFETY DATA SHEET

Product Nalco 84TB-227

SECTION 1 – PRODUCT IDENTIFICATION

Trade Name Nalco 84TB-227 Paint Stripper Formula No.

Synonyms A cyclic amide

Chemical Family Organic

SECTION 2 – HAZARDOUS INGREDIENTS

MATERIAL OR COMPONENT	%
None	

SECTION 3 – PHYSICAL PROPERTIES

Boiling Point, 760 mm Hg 399°F	Melting Point Not applicable
Specific Gravity (H_2O=1) 1.03	Vapor Pressure 0.3 mm Hg @ 20°C
Vapor Density (Air=1) No data	Solubility in H_2O, % by Wt. Miscible
% Volatiles By Vol. 100%	Evaporation Rate (Butyl Acetate=1) 0.06

Appearance and Odor
Water like, slight amine odor

SECTION 4 – FLAMMABILITY AND EXPLOSIVE PROPERTIES

Flash Point (Test Method)
199°F (PMCC), 204°F (OC)

Flammable Limits in Air, % by Vol.	Lower		Upper	
360-370°F	2.18		12.24	

Extinguishing Media
None

Special Fire Fighting Procedures
None

Unusual Fire and Explosion Hazard
None

SECTION 5 – HEALTH HAZARD DATA

Threshold Limit Value
None established for the product.

Effects of Overexposure
Causes eye irritation and burns. Repeated skin contact can cause skin irritation.

EMERGENCY AND FIRST AID PROCEDURES

Eyes
Immediately flush with water for at least 15 minutes. Call a physician at once.

Skin
Wash thoroughly with soap and water.

Ingestion
Induce vomiting. Give water. Call a physician.

Inhalation
None

FORM 307 (11-76)

(Continued on Reverse Si

NALCO CHEMI L COMPANY
2901 BUTTERFIELD ROAD BROOK, ILLINOIS 60521

MATERIAL SAFETY DATA SHEET

Product Nalco 84TB-227

SECTION 6 — REACTIVITY DATA

Stability: Stable ☒ Unstable ☐ Conditions to Avoid None

Materials to Avoid None

Hazardous Decomposition Products None

Hazardous Polymerization: Will Not Occur ☒ May Occur ☐ Conditions to Avoid

SECTION 7 — SPILL OR LEAK PROCEDURES

Steps to Take in Case Material is Released or Spilled Contain with absorbent material.

Waste Disposal Method No special method. Consult local, state and federal regulations for appropriate disposal methods. This product is not regulated under RCRA.

SECTION 8 — SPECIAL PROTECTION INFORMATION

Type of Respiratory Protection Required None normally required

Ventilation: Local Exhaust ☐, Mechanical (General) ☐, Special (Specify) Other (Specify)

Protective Gloves Neoprene Eye Protection Goggles, face shield

Other Protective Equipment None

SECTION 9 — SPECIAL PRECAUTIONS

Handling and Storage Precautions None

Other Precautions Do not take internally. Avoid eye contact.

Prepared By Title Toxicologist Date 10/1/84

Similar to Form OSHA-20 EMERGENCY TELEPHONE NUMBER — (312) 920-1510

Page 8

Material Safety Data Sheet

BASF Wyandotte Corporation

100 Cherry Hill Road
Parsippany, New Jersey 07054
201/263-3400

SECTION I

140641

CHEMICAL NAME 1-Methyl-2-Pyrrolidone

TRADE NAME N-Methylpyrrolidone

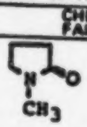
SYNONYMS N-Methyl-2-Pyrrolidone

CHEMICAL FAMILY Cyclic Amine

MOLECULAR WEIGHT 99.1

CAS REGISTRY NO. [872-50-4]

FORMULA



SECTION II - INGREDIENTS

NAME	%	TLV	TOXICOLOGICAL DATA
N-Methyl-2-Pyrrolidone	100	100ppm*	Rat, Oral LD_{50}: 3.6 g/kg Rabbit, Dermal LD_{50}: 8 g/kg , Rabbit, Eyes: Moderate Irritation Rabbit, Skin: Mild Irritation

*MAK value, 1981 (West Germany)

SECTION III - PHYSICAL DATA

Boiling/Melting Point @ 760 mm Hg	202°C	pH	7.7-8.0 (100 gm/l water)
Vapor Pressure mm Hg @ 20°C	< 1 mbar	Vapor Density 3.4	
Specific Gravity or Bulk Density	1.03 g/cm³	Freezing Point - 25°C	
Solubility in Water	Complete		
Appearance	Colorless Liquid	Odor	Amine Intensity Mild

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (TEST METHOD)	91°C (ASTM D 93-73)			AUTOIGNITION TEMPERATURE	270°C (DIN 51794)
FLAMMABILITY LIMITS IN AIR (% BY VOL.)		LOWER	1.3	UPPER	9.5
EXTINGUISHING MEDIUM	☒ Water Fog ☒ Foam ☒ CO_2 ☒ Dry Chemical ☐ Other				
SPECIAL FIREFIGHTING PROCEDURES	Firefighters should be equipped with self-contained breathing apparatus and turn-out gear.				
UNUSUAL FIRE AND EXPLOSION HAZARDS	Low, when exposed to heat or flames. Can react with oxidizing materials.				

EMERGENCY TELEPHONE NUMBER

CHEMTREC: 800-424-9300

(201) 263-3400

This number is available days, nights, weekends, and holidays.

F 1876 REV. 2/81

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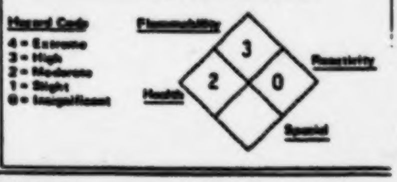
SAVOGRAN

P.O. Box 130, Norwood, Mass. 02062
Telephone: (617) 762-5400

DATA FOR HAZARDS INFORMATION LABEL



MATERIAL SAFETY DATA SHEET

TRADE NAME: SAVOGRAN STRYPEEZE SEMI PASTE

EFFECTIVE DATE:
NOVEMBER, 1984

CHEMICAL NAME: mixture C.A.S. No.: none CLASS: PAINT AND VARNISH REMOVER

DOT SHIPPING NAME and LABELING: Paint Related Material; Hazard Class: Flammable liquid; DOT specific packaging requirements: 173.128; exceptions: 173.118 & 173.128; DOT labeling requirements: quarts or smaller ORM-D; Gallons or larger: Flammable Liquid; I.D. No: NA 1263

SECTION 2 HAZARDOUS INGREDIENTS

	C.A.S. No	Wt %	TLV units
Methylene Chloride	75-09-2	< 20	500 ppm OSHA 100 ppm ACGIH
Methanol	67-56-1	< 30	200 ppm OSHA
Toluol	108-88-3	< 40	200 ppm OSHA 100 ppm ACGIH
Acetone	67-64-1	< 25	1000 ppm OSHA
Paraffin Wax	8002-74-2	< 5	5 mg/m^3 for oil mist in air ACGIH

SECTION 3 PHYSICAL DATA

Initial Boiling point: 104°F
Vapor Pressure: Retarded
Vapor Density: Heavier than air
Solubility in water: Appreciable

Specific Gravity: @ 60/60°F: 0.88
Percent Volatile: above 90%
Evaporation Rate: Less than ether
Appearance: Thickened, orange liquid, aromatic odor

SECTION 4 FIRE AND EXPLOSION DATA

FLASH POINT: Initial above 80°F. T.O.C. for fresh material. Material exposed to air for some time and residues may have much lower flash point.

FLAMMABLE LIMITS: unknown

EXTINGUISHING MEDIA: Water fog, regular foam, carbon dioxide or dry chemical

HAZARDOUS DECOMPOSITION PRODUCTS: May form toxic materials: carbon dioxide, carbon monoxide, various hydrocarbons, hydrogen chloride, small amounts of phosgene and chlorine.

SPECIAL FIREFIGHTING PROCEDURES: Wear self-contained breathing apparatus with full face piece operated in pressure-demand or other positive pressure mode. Straight water stream will spread fire.

UNUSUAL FIRE AND EXPLOSION HAZARDS: Vapors are heavier than air and may travel along the surface, collect in low areas and may be moved by ventilation and may ignite explosively at locations far removed from handling location. KEEP AWAY FROM SPARKS AND OPEN FLAMES. Use only in explosion proof areas or turn off electricty. DO NOT smoke or permit others o do so. DO NOT operate electric switches or motors. PREVENT metal objects from striking other metal objects which may cause sparks. TURN OFF pilot lights, electric igniters and all other flames. Vapors contacting flame, sparks or hot surfaces may ignite explosively or product gases which are toxic and are corrosive to metals. DO NOT use welding or cutting torches on or near containers [empty or full] because product, including residue, can ignite explosively.

SECTION 5 HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE: See Section 2

EFFECTS OF OVEREXPOSURE:

Eyes: Can cause severe irritation, redness, tearing, blurred vision. May cause transient injury to cornea.

Skin: Short contact - no irritation. Prolonged or frequently repeated contact can cause irritation, defatting, dermatitis.

Inhalation: Excessive inhalation of vapors can cause nasal and respiratory irritation, dizziness, weakness, fatigue, headache, nausea, unconsciousness and asphyxiation.

Swallowing: Aspiration of material into the lungs can cause chemical pneumonitis which can be fatal. Ingestion can cause blindness, nausea, vomiting, diarrhea, gastronintestinal irritation and death.

CAUTION: DRINKING ALCOHOL SHORTLY BEFORE, DURING OR AFTER EXPOSURE TO SOME SOLVENTS MAY CAUSE UNDESIRABLE EFFECTS.

FIRST AID:

Skin contact: Wash thoroughly with soap and water. Thoroughly launder contaminated clothing before reuse.

Eye contact: Flood with plenty of water with eye lids held open for at least 15 minutes and get medical attention promptly.

Inhalation: If illness occurs, remove patient to fresh air. If breathing is difficult give oxygen. If breathing has stopped start artificial respiration. Call physician immediately.

Swallowing: Immediately give 1 or 2 glasses of water and call physician, hospital emergency room or poison control center for way to induce vomiting. Get medical attention promptly. Never give anything by mouth to an unconscious person. Aspiration of material into lungs can cause chemical pneumonitis which can be fatal.

SECTION 6 REACTIVITY DATA

STABILITY: Stable

HAZARDOUS POLYMERIZATION: Will not occur

INCOMPATIBILITY (materials to avoid): Strong oxidizing agents (e.g. Nitric acid, permanganates, etc.) strong alkalies (e.g. NaOH, ammonia, etc.), strong acids (e.g. HCl, Sulfuric, etc.).

CONDITIONS TO AVOID: See "SECTION 4 - UNUSUAL FIRE AND EXPLOSION HAZARDS."

SECTION 7 SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLIED: Review "SECTION 4 - UNUSUAL FIRE AND EXPLOSION HAZARDS."

SMALL SPILLS: Wipe up or scrape up any material. Wash area thoroughly with detergent and water; ventilate adequately with good fresh air movement at floor level.

LARGE SPILLS: Wear proper protective equipment. Stop spill at source, dike area of spill to keep from spreading and keep out of ground water and stream. Transfer material to metal containers. Absorb remainder with sand, clay, earth, floor absorbent or other material and shovel into containers. Then wash area thoroughly with water and detergent. Ventilate adequately with good fresh air movement at floor level. DO NOT restart pilot lights or operate electrical devices or other sources of sparks, flames or heat until all vapors (odors) are gone.

SECTION 7 SPILL OR LEAK PROCEDURES (continued)

WASTE DISPOSAL METHOD: Dispose of used remover and sludge as spent solvent to a reclaimer. Burn wiping materials in approved incinerator or alternately they may be buried in an approved land fill or they may be allowed to evaporate dry at a safe distance from buildings if local, state and federal regulations permit.

SECTION 8 SPECIAL PROTECTION INFORMATION

VENTILATION: The vapors are heavier than air and due care must be exercised to prevent them from collecting in low, unventilated areas. Vapors may travel along the floor (even under and around closed doors). Adequate ventilation must be provided with good fresh air movement at floor level by normal cross ventilation or preferably explosion proof exhaust fans. LIMIT concentration of any solvent in air to TLV - see Section 2.

RESPIRATORY PROTECTION: At vapor concentrations below 100 ppm none needed. For levels up to 2% for 1/2 hour or less, a suitable full-face mask with canister for organic vapors and methanol should be used. Above 2% and emergencies, an approved self-contained breathing apparatus with a full face piece operated in a pressure demand or other positive pressure mode is advised. (See your safety equipment supplier.)

GLOVES: Industrial quality cotton lined neoprene gloves with close fitting wristlets.

EYE PROTECTION: Chemical goggles or safety glasses with side shield. Eye-wash stations and safety showers should be readily available. Plastic glasses may be dissolved by paint removers and other solvents.

OTHER PROTECTIVE EQUIPMENT: No special protective clothing needed; however, wear long sleeved shirts and long pants to protect skin against splashes and spills.

SECTION 9 SPECIAL PRECAUTIONS

HANDLING AND STORING: Store in cool place, out of hot sun and below 90°F. All containers are subject to damage in storage and transit. Damaged containers may start leaking immediately or at a later time. DO NOT store flammable materials in areas with widely fluctuating temperatures and DO NOT store where vapors may come in contact with flames, sparks, or heat. Flammable materials should not be stored in below ground areas that can not be adequately ventilated at floor level. DO NOT use cutting or welding torches near full or empty containers.

EMPTIED CONTAINERS: Emptied containers may retain product residues (e.g. vapor and liquid or solids); therefore, all precautions given in this sheet must be observed. If possible emptied container of 55 gallons or more should be given to reconditioner for cleaning.

NOTE: Judgement of potential hazards of this mixture is based on information available about individual components listed under SECTION 2 - HAZARDOUS INGREDIENTS. Direct testing of mixture has not been done. Flash point has been tested.

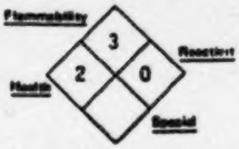
Information given herein is believed to be accurate and is given in good faith; however, no warranty either expressed or implied is made. It is strongly suggested that users confirm in advance of need that the information is current and applicable to their situation.

JLG

SAVOGRAN
P.O. Box 130, Norwood, Mass. 02062
Telephone: (617) 762-5400

DATA FOR HAZARDS INFORMATION LABEL

Hazard Code
4 = Extreme
3 = High
2 = Moderate
1 = Slight
0 = Insignificant



MATERIAL SAFETY DATA SHEET

TRADE NAME: SAVOGRAN KUTZIT

EFFECTIVE DATE: NOVEMBER, 1984

CHEMICAL NAME: mixture **C.A.S. No.:** none **CLASS:** PAINT AND VARNISH REMOVER

DOT SHIPPING NAME and LABELING: Paint Related Material; Hazard Class: Flammable liquid; DOT specific packaging requirments: 173.128; exceptions: 173.118 & 173.128; DOT labeling requirments: quarts or smaller ORM-D; Gallons or larger: Flammable Liquid; I.D. No: NA 1263

SECTION 2 HAZARDOUS INGREDIENTS

	C.A.S. No	Wt %	TLV units
Methylene Chloride	75-09-2	< 30	500 ppm OSHA 100 ppm ACGIH
Methanol	67-56-1	< 30	200 ppm OSHA
Toluol	108-88-3	< 30	200 ppm OSHA 100 ppm ACGIH
Acetone	67-64-1	< 30	1000 ppm OSHA
Paraffin Wax	8002-74-2	< 2	5 mg/m³ for oil mist in air ACGIH

SECTION 3 PHYSICAL DATA

Initial Boiling point: 104°F
Vapor Pressure: Retarded
Vapor Density: Heavier than air
Solubility in water: Appreciable

Specific Gravity: @ 60/60°F: 0.90 approx.
Percent Volatile: above 90%
Evaporation Rate: Less than ether
Appearance: Blue liquid with white solids, aromatic odor.

SECTION 4 FIRE AND EXPLOSION DATA

FLASH POINT: Initial above 80°F. T.O.C. for fresh material. Material exposed to air for some time and residues may have much lower flash point.

FLAMMABLE LIMITS: unknown

EXTINGUISHING MEDIA: Water fog, regular foam, carbon dioxide or dry chemical

HAZARDOUS DECOMPOSITION PRODUCTS: May form toxic materials: carbon dioxide, carbon monoxide, various hydrocarbons, hydrogen chloride, small amounts of phosgene and chlorine.

SPECIAL FIREFIGHTING PROCEDURES: Wear self-contained breathing apparatus with full face piece operated in pressure-demand or other positive pressure mode. Straight water stream will spread fire.

UNUSUAL FIRE AND EXPLOSION HAZARDS: Vapors are heavier than air and may travel along the surface, collect in low areas and may be moved by ventilation and may ignite explosively at locations far removed from handling location. KEEP AWAY FROM SPARKS AND OPEN FLAMES. Use only in explosion proof areas or turn off electricty. DO NOT smoke or permit others to do so. DO NOT operate electric switches or motors. PREVENT metal objects from striking other metal objects which may cause sparks. TURN OFF pilot lights, electric igniters and all other flames. Vapors contacting flame, sparks or hot surfaces may ignite explosively or product gases which are toxic and are corrosive to metals. DO NOT use welding or cutting torches on or near containers [empty or full] because product, including residue, can ignite explosively.

SECTION 5 HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE: See Section 2

EFFECTS OF OVEREXPOSURE:

Eyes: Can cause severe irritation, redness, tearing, blurred vision. May cause transient injury to cornea.

Skin: Short contact - no irritation. Prolonged or frequently repeated contact can cause irritation, defatting, dermatitis.

Inhalation: Excessive inhalation of vapors can cause nasal and respiratory irritation, dizziness, weakness, fatigue, headache, nausea, unconsciousness and asphyxiation.

Swallowing: Aspiration of material into the lungs can cause chemical pneumonitis which can be fatal. Ingestion can cause blindness, nausea, vomiting, diarrhea, gastronintestinal irritation and death.

CAUTION: DRINKING ALCOHOL SHORTLY BEFORE, DURING OR AFTER EXPOSURE TO SOME SOLVENTS MAY CAUSE UNDESIRABLE EFFECTS.

FIRST AID:

Skin contact: Wash thoroughly with soap and water. Thoroughly launder contaminated clothing before reuse.

Eye contact: Flood with plenty of water with eye lids held open for at least 15 minutes and get medical attention promptly.

Inhalation: If illness occurs, remove patient to fresh air. If breathing is difficult give oxygen. If breathing has stopped start artificial respiration. Call physician immediately.

Swallowing: Immediately give 1 or 2 glasses of water and call physician, hospital emergency room or poison control center for way to induce vomiting. Get medical attention promptly. Never give anything by mouth to an unconscious person. Aspiration of material into lungs can cause chemical pneumonitis which can be fatal.

SECTION 6 REACTIVITY DATA

STABILITY: Stable

HAZARDOUS POLYMERIZATION: Will not occur

INCOMPATIBILITY (materials to avoid): Strong oxidizing agents (e.g. Nitric acid, permanganates, etc.) strong alkalies (e.g. NaOH, ammonia, etc.), strong acids (e.g. HCl, Sulfuric, etc.).

CONDITIONS TO AVOID: See "SECTION 4 - UNUSUAL FIRE AND EXPLOSION HAZARDS."

SECTION 7 SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLIED: Review "SECTION 4 - UNUSUAL FIRE AND EXPLOSION HAZARDS."

SMALL SPILLS: Wipe up or scrape up any material. Wash area thoroughly with detergent and water; ventilate adequately with good fresh air movement at floor level.

LARGE SPILLS: Wear proper protective equipment. Stop spill at source, dike area of spill to keep from spreading and keep out of ground water and stream. Transfe material to metal containers. Absorb remainder with sand, clay, earth, floor absorbent or other material and shovel into containers. Then wash area thoroughly with water and detergent. Ventilate adequately with good fresh air movement at floor level. DO NOT restart pilot lights or operate electrical devices or other sources of sparks, flames or heat until all vapors (odors) are gone.

SECTION 7 SPILL OR LEAK PROCEDURES (continued)

WASTE DISPOSAL METHOD: Dispose of used remover and sludge as spent solvent to a reclaimer. Burn wiping materials in approved incinerator or alternately they may be buried in an approved land fill or they may be allowed to evaporate dry at a safe distance from buildings if local, state and federal regulations permit.

SECTION 8 SPECIAL PROTECTION INFORMATION

VENTILATION: The vapors are heavier than air and due care must be exercised to prevent them from collecting in low, unventilated areas. Vapors may travel along the floor (even under and around closed doors). Adequate ventilation must be provided with good fresh air movement at floor level by normal cross ventilation or preferably explosion proof exhaust fans. LIMIT concentration of any solvent in air to TLV - see Section 2.

RESPIRATORY PROTECTION: At vapor concentrations below 100 ppm none needed. For levels up to 2% for 1/2 hour or less, a suitable full-face mask with canister for organic vapors and methanol should be used. Above 2% and emergencies, an approved self-contained breathing apparatus with a full face piece operated in a pressure demand or other positive pressure mode is advised. (See your safety equipment supplier.)

GLOVES: Industrial quality cotton lined neoprene gloves with close fitting wristlets.

EYE PROTECTION: Chemical goggles or safety glasses with side shield. Eye-wash stations and safety showers should be readily available. Plastic glasses may be dissolved by paint removers and other solvents.

OTHER PROTECTIVE EQUIPMENT: No special protective clothing needed; however, wear long sleeved shirts and long pants to protect skin against splashes and spills.

SECTION 9 SPECIAL PRECAUTIONS

HANDLING AND STORING: Store in cool place, out of hot sun and below 90°F. All containers are subject to damage in storage and transit. Damaged containers may start leaking immediately or at a later time. DO NOT store flammable materials in areas with widely fluctuating temperatures and DO NOT store where vapors may come in contact with flames, sparks, or heat. Flammable materials should not be stored in below ground areas that can not be adequately ventilated at floor level. DO NOT use cutting or welding torches near full or empty containers.

EMPTIED CONTAINERS: Emptied containers may retain product residues (e.g. vapor and liquid or solids); therefore, all precautions given in this sheet must be observed. If possible emptied container of 55 gallons or more should be given to reconditioner for cleaning.

NOTE: Judgement of potential hazards of this mixture is based on information available about individual components listed under SECTION 2 - HAZARDOUS INGREDIENTS. Direct testing of mixture has not been done. Flash point has been tested.

Information given herein is believed to be accurate and is given in good faith; however, no warranty either expressed or implied is made. It is strongly suggested that users confirm in advance of need that the information is current and applicable to their situation.

JLG

APPENDIX D

TOXICITY DATA - STRIPPER CHEMICALS

84TB-227 -- NALCO CHEMICAL COMPANY

The identities of the ingredients of this stripper have not been revealed. Manufacturer claims that it is "a cyclic amide." There is no Threshold Limit Value (TLV) established for this product according to the manufacturer's Material Safety Data Sheet (MSDS) (1). It is an eye and skin irritant. The MSDS also claims it is not regulated under RCRA. The Advance Technical Data Sheet from Nalco claims there are no heavy metals or EPA regulated solvents (2).

M-PYROL 1140641 -- GAF CORPORATION

This is not a formulation, but a 99.5% pure liquid form of N-methylpyrrolidone. GAF, in their Summary of Toxicity Information report (3) that it is mildly to moderately toxic by ingestion and is a skin irritant. Acute dermal toxicity tests have shown that is not in the range ordinarily classified as toxic by this route under the Federal Hazardous Substances Act. It is an eye irritant but permanent eye damage has not occurred in tests. It is not a mutagen as measured by the Ames Test (3). In 1976, the intraperitoneal administration of N-methylpyrrolidone showed teratogenic effects (4). Subsequent studies conducted in 1982, using the dermal route of application showed no teratogenic effects or effects on the dams at 75 mg/kg and 237 mg/kg of body weight in Sprague-Dawley rats(5). An EPA evaluation tentatively assigns a conservative 25 mg/kg as the no-effect level. GAF, using the Warburg respirometry technique, have demonstrated that M-Pyrol is biodegraded by raw sewage bacteria, according to GAF Product Information Sheets (3).

S-26 -- ENTHONE, INC.

S-26 has the same major constituents as MS-111. However, the concentration of methylene chloride is greatly reduced. Methylene chloride is 50%; phenol is 20% and formic acid is 5%. This stripper is formulated to be miscible with water, forming a clear fluid at 1:1 dilution. This property of the stripper was designed into the formulation. The manufacturer recommends a 1:6 dilution with water and claims the formulation works in a range from 1:4 to 1:20 dilutions (6). See MS-111 for more information.

STRIPEEZE -- SAVOGRAN COMPANY

Stripeeze contains a reduced amount of methylene chloride, only 20%. See MS-111 for additional information. It contains less than 40% toluene according to the MSDS. Toluene is included in the determination of TTO (Total Toxic Organics) under 40 CFR 413 (7). It is currently listed in the Registry of Toxic Effects of Chemical Substances (RTECS) to be a mutagen, tumorigen, teratogen and skin and eye irritant. However, RTECS has not been peer-reviewed. Toluene is currently under test through the National Toxicology Program Carcinogenesis Study. The ACGIH (American Conference of Government Industrial Hygienists) recommends a TWA of 100 ppm. OSHA currently has set 200 ppm for TWA. Stripeeze contains less than 30% methanol. OHMTADS reports that it will biodegrade very rapidly. There is no direct evidence that it is a carcinogen, but it is highly toxic when ingested. Human oral LDLo is 340 mg/kg as reported by RTECS. RTECS also lists mutagen and teratogen data. The OSHA Standard is 200 ppm TWA (9).

Stripeeze contains less than 25% acetone. It is an irritant, especially bronchial, however OSHA has currently set the TWA at 1000 ppm. There is one study in RTECS that reports teratogenic data. The mutagenic level is very high, one study reports 40 grams per liter (9).

KUTZIT -- SAVOGRAN COMPANY

Kutzit has the same constituents as Stripeeze (above), except that the percentage composition is slightly different. The MSDS lists methylene chloride, toluene, methanol, and acetone as all being under 30% and paraffin wax as less than 2%. See discussion above.

QUICK STRIP #8 — MITCHELL BRADFORD CHEMICAL COMPANY

Quick Strip #8 contains 60% methylene chloride and an undisclosed acid. See discussion under MS-111 for methylene chloride.

MS-111 — MILLER-STEPHENSON CHEMICAL COMPANY

MS-111 contains 85% methylene chloride, 10% phenol, 5% formic acid and a surfactant, (<%1). Methylene chloride and phenol are both included in the determination of TTO (7). OHMTADS (Oil and Hazardous Materials Technical Assistance Data Service) reports that methylene chloride is probably not biodegradable, but that 1ppm solutions of phenol are (8). Methylene chloride is currently under study by EPA under TSCA to determine if methylene chloride poses an unreasonable risk of cancer,(10) and under the Clean Air Act to determine if it should be added to the list of hazardous air pollutants (11). RTECS lists methylene chloride as a tumorigen, mutagen, teratogen and skin and eye irritant. The current OSHA standard is 500 ppm TWA, but 75 ppm has been recommended by the ACGIH (9). MSDS's submitted by the various manufacturers recommend 200-250 ppm TWA.

Phenol is also considered a tumorigen, mutagen, teratogen, and skin and eye irritant by RTECS. Phenol has a very low TWA, 5ppm under the OSHA standard (9). The Department of Transportation requires a "poison" label (8). Oral toxicity for humans is 140 mg/kg as reported in RTECS. The

National Cancer Institute reports negative results in the carcinogenesis bioassays performed in mice and rats (9).

Formic acid is the third component of MS-111. OHMTADS reports that it biodegrades moderately fast and is highly toxic via ingestion or inhalation. It is a strong irritant (8). RTECS reports additionally that it may be a mutagen. The current OSHA standard is 5ppm TWA (9).

ALM -- OAKITE PRODUCTS, INC.

Oakite ALM is an alkaline mixture(pH=13) of <5% tributyl phosphate, furfuryl alcohol <10%, monoethanolamine, 10% and less than 1% sodium hydroxide. Tributyl phosphate, is a widely used plasticizer has 3000 mg/kg LD50 in rats according to RTECS and one study reported 12600mg/kg for teratogenic effects (9). The TWA is 200 ppb probably because of eye and mucous membrane irritation.

Furfuryl alcohol is unstable in water (12) and should biodegrade well according to OHMTADS. OHMTADS also suggests moderate toxicity for this compound (8). It is an eye and skin irritant and OSHA has set the TWA at 50ppm. there is one mutagen study reported in RTECS (9).

Monoaminethanol is very strong eye and skin irritant and OSHA has set the air standard at 3ppm TWA (9). No other toxicological information has been reported about this compound. DOT considers it a corrosive material (8).

Sodium hydroxide is a very minor component, probably added to achieve the correct pH in the formulation. It is a corrosive material according to DOT (8). chief routes of toxicity is inhalation of dust from solids and ingestion (8).

Overall, this formulation has no compounds that have been reported to show long term health effects upon exposure to environmental levels. These components however, do have a very high potential for serious health effects in workers because of the corrosive nature of the material. Use in a properly ventilated system with protective equipment would eliminate this problem.

FHS -- OAKITE PRODUCTS, INC.

FHS contains 35% butyl cellusolve (2-butoxyethanol), 15% formic acid, (See MS-111.) 10% diisobutyl ketone, less than 5% hydrofluoric acid and dodecylbenzenesulfonic acid in 10% mixed aromatic hydrocarbons (13). The mixture is acidic, pH is approximately 1.0.

The principal ingredient, butyl cellusolve is a skin and eye irritant. The OSHA standard is 50ppm TWA. Inhalation studies in rats show some teratogenic effects at 200 ppm (9). (Reported in RTECS). It is a poison when ingested orally and may be absorbed through skin (8). May degrade moderately fast (8).

Hydrofluoric acid is a corrosive material with strong irritation potential. The TCLo for man by inhalation is 110 ppm/1M and it is a suspected mutagen and teratogen (9). OHMTADS reports that natural alkalinity will slowly dissipate the acidity (8). The OSHA Standard is 3 ppm TWA. DOT require a "poison," "poison gas" and "corrosive" label (8).

Diisobutyl ketone is listed as a skin and eye irritant by RTECS (9); the OSHA Standard is 50 ppm TWA, but 25 ppm has been recommended. OHMTADS reports that it is a mild chronic irritant and inhalative toxin with low degrees of hazard to public health. OHMTADS also claims that this like other ketones should degrade well in the environment (8).

Dodecylbenzenesulfonic acid is an irritant and is moderately toxic with ingestion. DOT requires "Corrosive" label. Has not shown any chronic toxicity in man (8).

Overall, this formulation has no compounds that have been reported to show long term health effects upon exposure to environmental levels. These components however, do have a very high potential for serious health effects to workers because of the corrosive nature of the material. Use in a properly ventilated system with protective equipment would eliminate this problem.